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Editors' Remarks

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Cosmos Wheel

by Leland Waldrip

Some claim God created it all,
A singularity burst at His call,
Others say a singularity, yes, true ,
But don't have need of a god, in lieu

Of a Big Bang flowering on its own,
From causes hidden, unknown.
And a whole cosmos infinitely here
Is as likely as sudden appear

From God's most omnipotent hand
Stars, planets, nebulae and land.
Romantic notions of genesis abound.
For each culture a story is found

And in between, a big bang explodes,
Blooms, expands 'til gravity's lodes
Contract to bring it crunching back
In the same old singularity track.

That complements its people's ways,
Helps them more fully live out their days.
But what I see, as a fact writ large,
Is that no god today is in charge

Of our lives in a personal way,
Unless her manner of having her say,
Of pulling strings that make us dance
Precisely imitates physics and chance.

No, for me it's good sense and feel,
For the cosmos form to be a wheel,
Rolling through that singularity
With awesome punctual regularity.

In each cycle lives one universe,
Its laws unique, for better or worse,
And life, it will, or life will want,
But its possibility will ever haunt.

And the wheel rolls on …

2003

****

Leland Waldrip♣

This 16th volume No.1 presents actual papers on two main topics of Journal specialization, namely, **Computer Simulation and Information Processing** and **Simulation of Business Decision Making.** Contributors of this issue represent scientific institutions of India, Lithuania, Latvia, Israel, Kazakhstan and Japan.

Our journal policy is directed on the fundamental and applied sciences researches, which are the basement of a full-scale modelling in practice.

This edition is the continuation of our publishing activities. We hope our journal will be interesting for research community, and we are open for collaboration both in research and publishing. We hope that Journal's contributors will consider the collaboration with the Editorial Board as useful and constructive.

EDITORS

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♣ **Leland Waldrip** - was born in 1936 in Northern Mississippi, USA. POETRY COLLECTIONS: "Satin Verses," "100 Sensible Reflections". GRIZ NIGHTMARE, the latest novel by R. Leland Waldrip has won a Certificate of Merit from Writer's Digest in 2000.

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FINANCIAL MODELS OF HUMAN BEHAVIOUR IN DESIGN OFFICE

Part I. Design Office as an Active Player

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The problem outlined in the paper refers to the theory of active systems [2] and centres on decision-making to optimally reallocate the award received by the design office, among subordinated PERT-COST projects. The decision-making enables not to have losers among any project entering the design office's portfolio. The design office stands here as an active player.

Keywords: active systems; system's utility; projects of equal and different importance; design office's portfolio; PERT-COST projects; active players

1. Introduction

We will call the system's utility a weighted linear function of the system's parameters with constant coefficients. The parameters are divided into:

- independent parameters, where for each parameter its value may be preset and may vary independently on other parameters' values;
- dependent parameters whose values may not depend uniquely on the values of independent parameters. However, when optimised (for the same values of independent parameters), they are solely dependent on those values.

Both independent and dependent parameters together with the coefficients of the utility function are externally pregiven.

We will use a multi-stage solution of harmonization problems to determine the system's utility [1, 4]. At the first stage a look-over algorithm to examine all feasible combinations of independent basic values, is implemented. The independent parameters' values obtained at that stage are used as input values at the second stage where *for each dependent parameter* a local subsidiary optimisation problem (the so-called *partial harmonization model* PHM) is solved in order to raise the system's utility as much as possible. Solving such a problem enables the *solely dependence* of the optimised value on any combination of independent input parameters. At the next stage the system's utility value is calculated by means of basic parameters' values obtained at the previous stages, with subsequent search for the extremum in order to determine the optimal combination of all basic parameters' values delivering the maximum to the system's utility.

2. Harmonization Model for PERT-COST Projects

For stochastic PERT-COST network projects three parameters are implemented in the model:

- the budget C assigned to the project which has to be redistributed among the project's activities;
- the due date D for the project to be accomplished;
- the project's reliability R, i.e., the probability of meeting its due date on time subject to the pre-assigned budget C.

The harmonization model's solution is achieved by means of implementing a two-level heuristic algorithm. At the upper level a cyclic coordinate search algorithm [1, 4] to determine the quasi-optimal couple (budget – due date) is suggested. At the bottom level a high-speed heuristic procedure [1] serving as a partial harmonization sub-model (PHM), is implemented: on the basis of input values (the assigned budget and the set due date) to maximize the probability of meeting the deadline on time by undertaking optimal budget reallocation among the project's activities.

We will calculate the project's utility by

$$U = \alpha_C \cdot [C_0 - C] + \alpha_D \cdot [D_0 - D] + \alpha_R \cdot [R - R_0], \tag{1}$$

where C_0, D_0 and R_0 are the least permissible budget, due date and reliability values which can be implemented in a PERT-COST project, while values C, D and R are the corresponding current values for a project under consideration. Linear coefficients α_C, α_D and α_R define additional partial utilities which the project obtains by refining its corresponding parameter by a unit's value. Note that parameters C and D are independent parameters since they can be preset beforehand independently on each other, while parameter R is practically defined by values D and C and, thus, is a dependent parameter.

According to [1, 3–4], all random activity durations are assumed to have a beta-distribution, with the p.d.f.:

$$p_{ij}(t) = \frac{12}{\left(b_{ij} - a_{ij}\right)^4} \left(t - a_{ij}\right)\left(b_{ij} - t\right)^2, \tag{2}$$

where $b_{ij} = \frac{B_{ij}}{c_{ij}}$ and $a_{ij} = \frac{A_{ij}}{c_{ij}}$, A_{ij} and B_{ij} being pregiven constants for each activity (i, j) entering the PERT-COST network model.

The harmonization model is as follows: determine optimal non-contradictive project parameters $C^{(opt)}$, $D^{(opt)}$ and $R^{(opt)}$ resulting in the maximal project's utility

$$\underset{\{C,D,R\}}{Max}\ U(G) = \underset{\{C,D,R\}}{Max} \left\{U_0 + \alpha_C (C_0 - C) + \alpha_D (D_0 - D) + \alpha_R (R - R_0)\right\} \tag{3}$$

subject to

$$C_{00} \le C^{(opt)} \le C_0, \tag{4}$$

$$D_{00} \le D^{(opt)} \le D_0, \tag{5}$$

$$R_{00} \ge R^{(opt)} \ge R_0. \tag{6}$$

Note that since the basic utility U_0 is a constant value which remains unchanged, it may be cancelled and, thus, the model satisfies

$$\underset{\{C,D,R\}}{Max}\ U(G) = \underset{\{C,D,R\}}{Max} \left\{\alpha_C (C_0 - C) + \alpha_D (D_0 - D) + \alpha_R (R - R_0)\right\} \tag{7}$$

subject to (4–6). Values C, D and R are called non-contradictive if budget C can be reassigned among the project activities to satisfy

$$\Pr\left\{T(G)_{c_{ij}} \le D\right\} = R \tag{8}$$

subject to

$$\sum_{(i,j)} c_{ij} = C. \tag{9}$$

Solving problem (3–7) can be carried out by solving two sequential problems: to determine an optimal budget value C and an optimal due date D (Problem 1) and to carry out the PHM (Problem 2) [1, 4].

Problem 1 centres on determining an optimal couple $\left(C^{(opt)}, D^{(opt)}\right)$ by means of a look-over algorithm that checks the feasibility of each possible combination (C, D). If the number of combinations is high enough and taking into account that:

- each combination requires a PHM solution, and
- problem 1 is a NP-complete one,

solving both problems on a look-over basis requires a lot of computational time [1]. To avoid this obstacle, we use a two-level high-speed approximate heuristic algorithm. At the upper level a heuristic simplified search procedure, e.g., a cyclic coordinate sub-algorithm [1, 3–4], has to be carried out in the two-dimensional space in order to determine an optimal combination (C, D). At the bottom level, a heuristic high-speed procedure to optimise the partial harmonization model $PHM/_{C,D}$ with independent input values C and D, has to be implemented. Thus, we substitute objective (7) by

$$\underset{C,D}{Max}\left\{ CCSA\{C,D\} \cup PHM/_{C,D} \Rightarrow U\left(C,D,R\right)\right\}, \qquad (10)$$

where $\bigcup$ stands for a unification sign.

As outlined above, parameters C and D are input values of the model as well as values $c_{ij\ \min}$, $c_{ij\ \max}$, A_{ij} and B_{ij}, $(i,j) \subset G(N,A)$. The problem is as follows: determine optimal reassigned budget values c_{ij} for each activity $(i,j) \subset G(N,A)$, to maximize the project's conditional reliability, i.e.,

$$\underset{\{c_{ij}\},\ \sum_{(i,j)} c_{ij}=C}{Max}\left[\Pr\left\{T\left(G\right)_{c_{ij}} \le D\right\}\right] \qquad (11)$$

subject to

$$c_{ij\ \min} \le c_{ij} \le c_{ij\ \max}, \qquad (12)$$

$$\sum_{(i,j)\subset G(N,A)} c_{ij} = C. \qquad (13)$$

The procedure of optimising problem (11–13) has been outlined in [1, 3–4].

3. Estimating the Utility of a Portfolio of PERT-COST Projects

We will consider a complicated hierarchical system comprising a variety of projects of different significance. Such projects usually emerge in constructing new industrial and populated areas, where the significance of certain local projects entering the system may undergo changes within the projects' realization. The latter often happens in the course of changing management policy as well as the economic situation.

Another harmonization model covers a simplified although important case when all projects happen to be of equal significance and do not undergo drastic changes in the course of their implementation. The harmonization model becomes simpler in usage, and is based on determining optimal utility values via minimax principles [1, 4].

Each project entering the portfolio comprises three essential, basic parameters which define the project's utility:

- budget C_k assigned to each project $G_k(N,A)$, $1 \le k \le n$;
- the appropriate due date D_k;
- reliability parameter $R_k(C_k, D_k)$,

$$R_k\left(C_k, D_k\right) = \underset{\left\{c\left(i,j\right)_k\right\}}{Max} \Pr\left\{T_k \le D_k \left| \sum_{\left(i,j\right)_k} c\left(i,j\right)_k = C_k \right.\right\}, \tag{14}$$

where T_k signifies the moment project $G_k\left(N, A\right)$ is completed (a random value), on condition that budget C_k is assigned to $G_k\left(N, A\right)$ and optimally reallocated between activities $\left(i, j\right)_k$. It goes without saying that relation $C_k > \sum_{\left(i,j\right)_k} c\left(i, j\right)_k$ holds, otherwise project $G_k\left(N, A\right)$ cannot be carried out.

For each k -th project its utility U_k is calculated as follows [1, 4]:

$$U_k = \alpha_{C_k}\left(C_{0k} - C_k\right) + \alpha_{D_k}\left(D_{0k} - D_k\right) + \alpha_{R_k}\left[R_k\left(C_k, D_k\right) - R_{0k}\right] , \tag{15}$$

where C_{0k}, D_{0k} and R_{0k} are the least permissible basic values that can be accepted in the course of the project's realization, $1 \le k \le n$, while α_{C_k}, α_{D_k} and α_{R_k} stand for local (partial) utilities per each parametrical unit.

4. Case of Different Projects' Importance

For a project management system with projects of different importance the harmonization problem with objective

$$J_1 = \sum_{k=1}^{n}\left(\eta_k \cdot U_k\right) \tag{16}$$

is outlined in [4].

Maximizing objective (16) means that the project management takes all possible measures first to support projects with higher priorities. Only afterwards it takes care of other, less important, projects.

For projects with different priorities the problem is as follows: for each k -th project determine optimal due date D_k and budget value C_k, $1 \le k \le n$, as well as optimal reassignment values for each activity $c\left(i, j\right)_k$, $\left(i, j\right)_k \subset G_k\left(N, A\right)$, to maximize objective:

$$\begin{aligned} Max\, J_1 &= \underset{\left\{C_k, D_k\right\}\left\{c\left(i,j\right)_k\right\}}{Max} \sum_{k=1}^{n}\left(\eta_k \cdot U_k\right) = \\ &= \underset{\left\{C_k, D_k\right\}\left\{c\left(i,j\right)_k\right\}}{Max} \left\{\sum_{k=1}^{n}\left[\eta_k \cdot \left[\alpha_{C_k}\left(C_{0k} - C_k\right) + \alpha_{D_k}\left(D_{0k} - D_k\right) + \alpha_{R_k}\left(R_k - R_{0k}\right)\right]\right]\right\} \end{aligned} \tag{17}$$

subject to

$$\sum_{k=1}^{n} C_k = C, \tag{18}$$

$$\sum_{\left\{\left(i,j\right)_k\right\}} c\left(i, j\right)_k = C_k, \tag{19}$$

$$c\left(i, j\right)_{k\ \min} \le c\left(i, j\right)_k \le c\left(i, j\right)_{k\ \max}, \tag{20}$$

$$C_{00k} \le C_k \le C_{0k}, \tag{21}$$

$$D_{00k} \le D_k \le D_{0k}, \tag{22}$$

$$R_{0k} \le R_k \le R_{00k}, \tag{23}$$

$$\left(C_k - C_{00k}\right)\rho_{kD_k} = R_k\left(C_k, D_k\right) - R_k\left(C_{00k}, D_k\right), \tag{24}$$

$$C_{00k} \geq \sum_{\{(i,j)_k\}} c(i,j)_{k\ \min}, \tag{25}$$

$$C_{0k} \leq \sum_{\{(i,j)_k\}} c(i,j)_{k\ \max},\ 1 \leq k \leq n. \tag{26}$$

Problem (17–26) has been solved in [1, 3–4].

5. Case of Projects with Equal Priorities

In case of projects with equal priorities we will implement another objective satisfying

$$J_2 = \underset{\{C_k, D_k\}}{Max}\ \underset{k}{Min}\ U_k. \tag{27}$$

Objective (27) means that for projects with equal significance the project management takes all measures to support the "weakest" projects on the account of the "stronger" and the "faster" ones. That means, in turn, implementing a policy resulting in control actions aimed on projects' levelling, in order to smooth the differing projects' utilities.

The problem of maximizing the portfolio's utility can be formalized as follows: for each k-th project determine budget value C_k and due date D_k, $1 \leq k \leq n$, to maximize utility of the project with the least utility value, namely,

$$J_2 = \underset{\{C_k, D_k\}}{Max}\ \underset{k}{Min}\ U_k = \tag{28}$$
$$= \underset{\{C_k, D_k\}}{Max}\ \underset{k}{Min}\left[\alpha_{C_k}\left(C_{0k} - C_k\right) + \alpha_{D_k}\left(D_{0k} - D_k\right) + \alpha_{R_k}\left(R_k - R_{0k}\right)\right]$$

subject to (18–26).

6. Human Behaviour Models in Stochastic Project Management

It can be well-recognized from [1-2, 4] that several projects at the lower level, managed simultaneously by a design office at the upper level, form a truly active system. Indeed, each project's team tries to gain as much as possible even when honouring the management's policy. After the project is realized and finished, the project's team may obtain several kinds of awards, namely,

- the award for high project's utility, and
- the award for delivering the product to the market in time, i.e., before the due date. The award value depends on the product's importance and on the situation on the market. Thus, the due date may undergo drastic changes.

As outlined in [1, 3–4] design office governs various resources (mostly financial ones) by means of distributing (and redistributing, if necessary) the latter among the projects to be realized simultaneously. This fully refers to PERT-COST projects which have been considered above.

Let us consider a particular case (from many other realistic ones) of the projects' competition. Assume that a projects' office at the upper level is in charge of several simultaneously realized PERT-COST type projects $G_i\left(N, A\right)$, $1 \leq i \leq n$, at the lower level. Projects G_i are of different importance and have different priority indices η_i. Assume, further, that at the end of all projects' realization the project management (design office level) receives two kinds of awards: $Aw\ I$ and $Aw\ II$:

- the award for the portfolio's utility is calculated by

$$Aw\ I = U_s \cdot \gamma_s, \tag{29}$$

where U_s is determined by (16), and γ_s is pregiven;

- the award for preserving the total office budget is calculated by

$$Aw\ II = \left(C_0 - C\right) \cdot \beta_s. \tag{30}$$

Here C is the budget which has been actually spent within the project's realization, and C_0 is the minimal budget for realizing the projects' portfolio determined at moment $t=0$. Index β_s, similarly to γ_s, is also pregiven. It can be well-recognized that part $Aw\ II$ may become negative.

As to projects G_i at the lower level, they, when finished, also obtain two kinds of awards, namely $Aw_i\ I$ and $Aw_i\ II$, $1 \le i \le n$, as follows:

- award $Aw_i\ I$ depends on the project's utility U_i and is calculated as follows

$$Aw_i\ I = U_i \cdot \gamma_i,\ 1 \le i \le n, \tag{31}$$

where U_i is determined by (16), and γ_i is pregiven;

- value $Aw_i\ II$ is the award for delivering the product developed by project G_i (call it henceforth $\Pr od_i$) to the market in order to meet the due date D_i. Value $Aw_i\ II$ is calculated by

$$Aw_i\ II = L_i + \beta_i \cdot (D_i - F_i), \tag{32}$$

where L_i is a constant pregiven value, F_i is the actual moment project G_i terminates, and value β_i is pregiven. It can be well-recognized that award $Aw_i\ II$ increases by decreasing F_i, and vice-versa.

Thus, the total award for the design office calculated at moment $t=0$, i.e., at the starting moment for the projects to be realized, is

$$Aw_s = U_s \cdot \gamma_s + (C_0 - C) \cdot \beta_s, \tag{33}$$

while for each project G_i, $1 \le i \le n$, the total award (at $t=0$ as well) is

$$Aw_i = U_i \cdot \gamma_i + L_i + \beta_i \cdot (D_i - F_i). \tag{34}$$

Assume, further, that at moment $t=0$ all the information about projects $G_i(N,A)$, $1 \le i \le n$, is available. Thus, for a more or less regular situation at the products' market, we start realizing projects G_i by means of determining the minimal budget C_0 and re-distributing the latter among the projects. Value C_0 enables solving problem (17–26) for projects with different priorities together with calculating the forecast utility value for the whole portfolio, as well as local utility values for each project $G_i(N,A)$, $1 \le i \le n$. After calculating values C_i, together with pregiven values D_i and p_i, the projects start functioning.

Assume, in addition, that a certain moment $t > 0$ it is recognized that for some or another reason for one of the projects G_ε, $1 \le \varepsilon \le n$, its output product $\Pr od_\varepsilon$ is greatly anticipated on the market. It is announced therefore that for each time unit before the due date D_ε the project, when accomplished, will obtain a very high additional award Aw_ε^*. Under such circumstances project G_ε will surely apply to the upper level in order to decrease the due date D_ε as much as possible, together with increasing the project's index η_ε (also as much as possible!). It goes without saying that the design office has to pay attention to such an application and to undertake decision-making in order to “harmonize” the benefits for the projects entering the portfolio. We suggest the harmonization procedure outlined in the next Section.

7. Procedure for a Project without Losers

The enlarged step-by-step procedure is as follows:

<u>Step 1</u>. For each project G_i, $1 \le i \le n$, calculate both awards $Aw_i I$ and $Aw_i II$ on the basis of the results obtained when implementing algorithm outlined in [1, 4] at $t=0$. Values $Aw_i I$ are obtained by taking into account calculated values U_i obtained by (16–26). Values $Aw_i II$ are obtained by using assumptions $F_i = D_i$, $1 \le i \le n$. After determining values $Aw_i I, II$ both awards are summarized to obtain a forecasting value $Aw_i^o = U_i \gamma_i + L_i$ for each project G_i, $1 \le i \le n$, at $t=0$.

Step 2. For the project management design office (upper level) calculate value $AwII$ by (30) on condition that relation $C = C_0$ will hold within the projects' realization.

Step 3. Resolve the initial problem (16–26) with new priority indices η_i and new due dates D_i (for project G_ε). Take into account that all projects G_i, $1 \le i \le n$, at moment $t = 0$ are partially realized and, thus, have to be inspected and updated. Calculate by means of inspection the total budget already spent at moment t for all projects. Call it henceforth $\overline{C}$. Determine by means of the algorithm outlined in [1, 4] the minimal budget to carry out the remaining updated projects at moment t with new amended indices η_i and D_i. Call that minimal budget C_t^*.

Step 4. Calculate at moment t the newly determined utility values U_{ti} for each updated project G_i, $1 \le i \le n$, taking into account that for G_ε the updated parameters are as follows:

- total value C^* is reallocated among the updated projects according to [4], and for each project G_i its budget is henceforth called C_{ti}^*, $\sum_{i=1}^{n} C_{ti}^* = C_t^*$;
- due dates D_i remain the same, besides for project G_ε, where D_ε has to be diminished to $D_{\varepsilon t} < D_\varepsilon$;
- indices η_i remain the same, besides for project G_ε, where η_ε has to be increased to $\eta_{\varepsilon t} > \eta_\varepsilon$;

Step 5. Calculate at moment t the corrected award values Aw_{ti} for each project G_i, including for project G_ε the additional award $\left(D_\varepsilon - D_{\varepsilon t}\right) \cdot Aw_\varepsilon^*$. Determining Aw_{ti} is carried out in Step 1.

Step 6. Calculate at moment t the newly corrected award for the design office

$$Aw_{ts} = \gamma_s \cdot \sum_{i=1}^{n} U_{ti} + \beta_s \cdot \left(C_0 - \overline{C} - \overline{\overline{C}}_t\right), \tag{35}$$

where $\overline{\overline{C}}_t$ denotes the budget actually spent within the period starting from t until the end of the projects' realization.

Step 7. Calculate for each project G_i, $1 \le i \le n$, the corresponding award differences $Aw_{ti} - Aw_i = \Delta_{ti}$. Note that $\Delta_{t\varepsilon}$ will be very high while for some other projects the difference Δ_{ti} may be negative.

Step 8. Calculate the award difference for the design office $\Delta_{ts} = Aw_{ts} - Aw_s$.

We suggest the following decision-making for the policy with no losers:

Project G_ε has to transfer from its award value the partial budget to fill up the losses for all projects G_i, $i \ne \varepsilon$, with negative values Δ_{ti}, as well as for the design office value Δ_{ts} in case $\Delta_{ts} < 0$.

As a matter of fact, many other human trade-off decision-makings may be considered and discussed as well. It can be well-recognized that the developed research fully complies with the methodological grounds outlined in [2], namely, with non-antagonistic games the projects are “playing” by means of human personnel behaviour.

Conclusions

It can be well-recognized that in the financial models of human behaviour outlined above the company acts as an active player. Thus, the active system under consideration is a single-level one.

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FORMALIZATION OF A RELIABLE ENTERPRISE DESIGN

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The methodology of enterprise's organizational structure formed on the base of the axiomatic approach is analysed in the given research. The proposed methodology allows determining the reliability according to mutual simple conformity of common referential activity to the complete referential process described it.

Keywords: enterprise's organizational structure, reference activity, reference process harmonization

1. Introduction

This paper is a conceptual study forming a basis for new foundations of management science. Such foundations are aimed at the construction of management provisions and theories. The fundamental idea of the study is formalization of the theory of management, i.e., a successive refinement of original problem to be able to exercise axiomatic approach when creating a theory fit for running efficient activities. Based on the approach, answers are given to such questions as “how a theory should be built to avoid the occurrence of any controversies therein?”, “why are exactly these proof techniques used?” The proof techniques are supported by the author’s investigations as well as by the results of papers by S. Beer, G. P. Schedrovitsky, E. Deming, I. Ansoff, S. Cammings, B. G. Litvak and others.

The essence of organization design as compared to traditional design is determined by the idea shaped in the form of a new, emerging phenomenon; the idea is driven by the present and the future pattern of the entire social system submerged into a specific environment. [1]. Reliability of an enterprise is its capability of maintaining operation under extremely far-reaching circumstances forming a particular context [2]. The establishment of a reliable enterprise is governed by the requirements posed by design and technological organizational culture; such requirements dictate a combination of natural and artificial constructs [3, 4, 5, 6, 7, 8]. Using such a combination is aimed at a particular understanding of the sense of project and technology, enabling one to make fundamental changes to external environment, taking into account the aggregate of system conditions, forms, and methods of solving the problems posed [9, 10]. Any fundamental change should be evaluated in terms of manageability, expressed by comparison between the efficiency [11] of reference activity and the effectiveness [12] of reference process when measuring the enterprise structure reliability level on the value basis [13]. In this respect, reference activity is a natural force seizing and compelling everything that falls into the total of sequences of selected items; to define such an activity, natural constructs are used. However, people accommodating themselves to a spontaneous process of development and change and selecting the most beneficial patterns of personal behaviour for themselves, want to control the process independently by organizing and restructuring the design proper in the best way if the movement starts to go wrong. In this case, the design is accomplished based on artificial constructs in accordance with definite items, the aggregate of which being juxtaposed to items of reference activity forms reference process. Figure 1 below shows the integrated reference activity and the consistent reference process harmonization scheme offered within the framework of this study.

In other words, developing and changing functional design in the context of a certain product manifests and should manifest itself, on the one hand, as a reference activity existing separate from people, seizing their occupation, and compelling it to its laws of spontaneous development, - and, on the other hand, as the reference process of conscious and meaningful standards of behaviour of people.

The considered scheme is an abstract model being a first-level one; its parameters are used as limitations for the creation of higher-level models. So far as one goes from one description level to another, any limitations and ambiguities are eliminated. It should be noted that some actions supporting the expected manageability are outlined within the framework of an abstract model. Such actions having strategic orientation are aimed at the transformation of contradictory styles of management into management principles [4]. At that, the object domain of specific organization is extended when classifying its pathologies at the level of dissipative structures [14, 15].

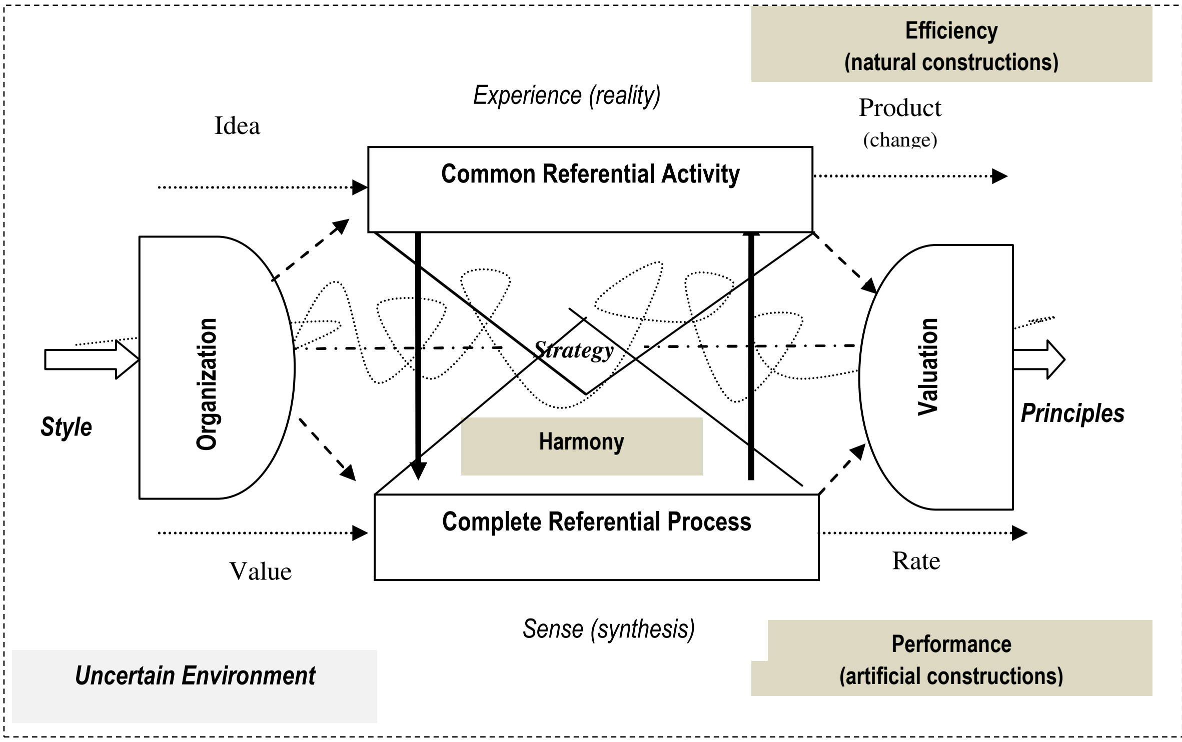

Figure 1. The reference activity and reference process harmonization scheme

Their studying allows one to specify foundations for the development of natural classifications of various systems and the selection of an object set of the system. Linking of such objects is performed within the framework of a cognitive model making the enterprise potential more precise, taking into account external factors. Elimination of external disconnectedness makes the relations occurring between objects more specific, which results in qualitative definiteness due to missing links being found. Upon the availability of such information awareness, a pragmatic model is developed, with the requirements of adaptation to fundamental changes inherent in its basis. When describing reference activity of an enterprise, reliable information should be obtained, serving as a basis for reproduction of self-organization properties both under an extremely favourable and an extremely unfavourable situation [16, 17].

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2. Imperfection of the Precise Theory of Value-Based Management

The efficiency of reference activity within the framework of a reliable enterprise is evaluated on the basis of value-based monitoring instruments [10, 13]. Such instruments in total are a set of generalized and – which is the most important – meaningfully considered notions forming a precise theory of value-based management. As a confirmation of this assertion, it would be enough to refer to the primary purpose of management which is just a rise in the value of enterprise with simultaneous preservation of the enterprise value on the competitive market; otherwise, one may consider capitalization mechanism within the framework of transformation of future economic benefits into current value etc. [19, 20, 21, 22].

The consideration of value-based management when reference activity is described in terms of a precise theory is governed by a certain language which in itself is a set of assertions, meaningful from the viewpoint of creation of added cost, and by the totality of theorems forming a subset language consisting of assertions in the given theory. Now, we turn out attention to a few definitions which can be attributed to the main theorems of value-based management [23, 24, 25, 26]. The cost of an enterprise is determined by the enterprise's capability of generating cash flow for a long period of time. All enterprises have both incoming and outgoing cash flows, i.e., such enterprises provide for a capital turnover either promoting or hampering the enterprise growth. Financing requirements with respect to an enterprise are connected with sustainable functioning of the enterprise: if any enterprise invests its undistributed profit into its fixed assets turnover, thus increasing its debenture capital in the amount sufficient to maintain constant leverage, – and if the assets produce revenues keeping up while the profits margin of products stays invariable – all that creates pre-requisites for a sustainable growth of the enterprise. Despite its 50-year history, the value-bases theory still doesn't allow one to single out any objects and actions that may be deemed accurate. Moreover, within the framework of such a theory some contradictions occur at the level of categories seeming elementary (at first glance) but, actually being core ones – such as selection of discounted cash flow (DCF) model, definition of planning horizon, calculation of discount rate. It is no coincidence that some new terms occur, the sense of which raises doubt when they are used in practice – despite their seeming pithiness. Let's enumerate some of those terms: "hexagram of value, "fair yield rate", "expectations-based value" [27, 28, 29].

The existence of contradictions casting some doubt on the grounds of value-based theory claims to pass over from a precise theory to the formal one. That would enable one not only to handle the base concepts with great care but to extend the general idea of reference activity at the expense of receiving instructions on taking efficient steps with respect to finite number of items.

3. Consideration of Value-Based Management in Terms of Formal Theory

The term "formal" emphasizes that reference activity object is considered in a purely formal manner, without any profound interpretation of symbols. Formal theory relies on a sequential realization of axiomatic approach which is based on only on information used in axioms. Moreover, it is not allowed to use any suppositions concerning theory objects – except those explicitly expressed in the form of axioms, which are considered as formal sequences of characters or expression. Lack of any ties and relations between characters creates a certain image of the problem extraction from text, enabling one not only to use constructive means of formulation of original expressions at the initial phase of establishment of an enterprise, but also to make the general formulation more precise. Within the framework of formal theory, to preclude any liberties when setting up the problem, it is necessary to provide for implementation of three principal stages:

1) to describe clearly the class of objects: determination of a set of well-formed expressions (or formulas) that constitute the language of theory (the set is preset by constructive means and, consequently, is enumerable);
2) with respect to described objects – to introduce the notion of order: singling out a subset of formulas being axioms of the theory (a set may be infinite; at any rate, it should not be decidable);
3) to describe the notion of ordering in terms of the system of local operations: setting up deduction rules of the theory $R(F_1,\ ...,\ F_n,\ G)$, presented as a calculable relation on a set of formulas. The formulas $F_1,\ ..,\ F_n$ are hypotheses of rule, while G is its consequence (conclusion).

Let us consider the original version of setting up the problem of value-based management in terms of formal theory. Let us assume that it is required to assess the value of enterprise, based on the cash flow discounting model FV_t on a mid-term horizon N under the conditions of a sustainable growth of the enterprise SGR at the discount rate $WACC$ approved by the top management [26, 30–35]. Table 1 shows the initial data based on which, a brief description of statement of the problem in terms of value-based management can be made.

Table 1. The initial statement of the problem of value-based management

No	Initial expression	Designation	Formula	Number of arguments
1	Planning horizon	T_{OK}, N	F_1^N	$N=6$
2	Model of operating enterprise	FV_t	F_2^K	$K=7$
3	Discounting rate	$WACC$, $CAPM$	F_3^L	$L=9$
4	Sustainable growth ratio	SGR	F_4^M	$M=7$
5	Direct capitalization (Gordon's model)	PV_{term_K}	G_1	6

The formulas $F_1^N,\ ...,\ F_4^M,\ G_1$ are in relation R_1; the formula G_1, characterizing the direct capitalization formula is directly deducible from $F_1^N,\ ..,\ F_4^M$ in compliance with the rule $\dfrac{F_1^N,\ ..,\ F_4^M}{G_1}$.

The proof of the formula G_1 in the formal theory is a deduction from an empty set of formulas, e.g., the deduction where only axioms [36] are used as initial formulas. We will designate the provability fact G_1 as $\mid -G_1$.

First, on the basis of axioms some proof methods are used, through which one kind of expressions is derived from the other. Further, so far as the problem is set up more precisely, when the formalization process actually starts, it is required to select axioms and rules of proof so that the formal theory would assume a profound sense. In the general case, finding a profound sense in the formal theory is connected with considering such a theory as a certain calculus wherein any method or calculation system would be based on a symbolic manipulation of expressions.

That's exactly the way from an empty set to an enumerable finite set of objects. Unlike the initial scenario of value-based management where the enterprise value was investigated, now we shall try to provide for an increase in the enterprise value, preserving the significance of the same enterprise at the same time, taking into account the main purpose of management and acting under the same conditions as we had under the initial scenario [24, 10, 21]. Table 2 contains characteristics of the description of the improved statement of the problem at the expense of a new assertion put forward, which is in essence a new axiom.

Table 2. Improvement of the initial statement of the problem of value-based management

No	Initial expression	Designation	Formula	Number of arguments
1	Planning horizon	T_{OK}, N	F_1^N	$N = 6$
2	Model of operating enterprise	FV_t	F_2^K	$K = 7$
3	Discount rate	$WACC$, $CAPM$	F_3^L	$L = 9$
4	Discounting rate	SGR	F_4^M	$M = 7$
5	McKinsee pentagram	ΔPV_I, ..., ΔPV_V	F_5^P	$P = 23$
6	Direct capitalization (Gordon's model)	PV_{term_K}	F_6^R	$R = 6$
7	Increment value of enterprise	$\Delta PV_{project}$	G_2	11

Derivation of formula G_2 took place not only at the expense of the introduction of a new axiom, an increase in the number of attributes and formulas and also a change of the deduction rule R_2 $\dfrac{F_1^N, \ .., \ F_6^R}{G_2}$ but also as a result of the disclosure of contents by way of creating additional opportunities of description of a set of objects.

At first glance it may seem that this approach does not pay any attention to meaningfulness and the truth, since any substantial interpretation of characters is missing. But, in effect, we obtain a certain guarantee of some more explicit initial assertions and uniqueness of conclusions being formulated. In other words, we act within the framework of a preset algorithm which not only includes an enumerating or confirmatory set of logical operations performed with respect to objects, but allows one to describe the finite set of objects.

The provability of the formula G_2 derived from formulas F_1^N, .., F_6^P according to R_2 rule is of a conditionally preset nature, since, by using a model of operating enterprise, it is quite difficult to set any substantiated standards based on which, the efficiency of reference activity can be determined.

That's why at the next iteration of value-based management it is necessary to pass over from the model of operating enterprise to a model of investment project [13]. An improved statement of the problem is reduced to an additional check of the value spread at the preset stage of enterprise functioning. We can write the checking condition in terms of investment appeal of the enterprise: $(IRR - WACC) \geq K_{kr}$ (see Table 3).

The analysis of the table contents has allowed us to state that we are facing an essential complication of the problem; at the same time, we rely on the absolute provability of the conclusion derived from the rule R_3 $\dfrac{F_1^N, \ .., \ F_9^{L_1}}{G_2}$, which allows us to record the following fact on the finite set of formulas: $F_1^N, \ .., \ F_9^{L_1} \Big| -G_3$.

Table 3. The third version of value-based management

No	Initial expression	Designation	Formula	Number of arguments of the formula
1	Planning horizon	T_{OK}, N	F_1^N	$N = 6$
2	Model of operating enterprise	FV_t	F_2^K	$K = 7$
3	Discounting rate	$WACC$, $CAPM$	F_3^L	$L = 72$
4	Sustainable growth ratio	SGR	F_4^M	$M = 7$
5	McKinsee pentagram	ΔPV_I, ..., ΔPV_V	F_5^P	$P = 23$
6	Direct capitalization (Gordon's model)	PV_{term_K}	F_6^R	$R = 6$

The continuation of Table 3

No	Initial expression	Designation	Formula	Number of arguments of the formula
7	Increment value of enterprise	$\Delta PV_{project}$	F_6^Q	$Q = 11$
8	Reduction base	N_1	$F_7^{N_1}$	$N_1 = 15$
9	Model of investment project	$FV_t^{'}$	$F_8^{K_1}$	$K_1 = 9$
10	Internal rate of return	IRR	$F_9^{L_1}$	$L_1 = 4$
11	Evaluation of investment appeal	$(IRR - WACC) \geq K_{kr}$	G_3	47

Some analogous expressions with a larger number of dimensions are obtained so far as we are plunging into the essence of value-based cost.

Generally, the formal theory of value-based management, hereinafter referred to as T-theory, in the context of accepted calculus is reduced to setting the i-th deduction rule $R_i\left(F_1^{k_1},\ ...,F_j^{k_j}\quad F_n^{k_n},\ G_i\right)$ on a set of formulas $F_1^{k_1},\ ..,\ F_n^{k_n}$ (with a preset number of attributes k_j, where $j = 1,\ \ ...,\ \ n$), which are the hypotheses of the i-th rule, as well as its conclusion, G_i.

If we juxtapose the contents of Tables 1 – 2, it will be quite easy to reveal that, once the new axioms are introduced, the number of initial expressions is increased as well as the number of objective instruments allowing one to obtain reliable information which will eventually be reflected on the quality of evidential base.

Therefore, applying the formal theory provisions when evaluating reference activity on the basis of instruments of value-based management have enabled one to obtain some objective basis for formulation of supported statements. Such statements should be built within the framework of a special technique, since they are well-formed grammatical sentences which reflect the sense put into the statements proper, disclosing their contents, – and are true or false.

Now, let us pass directly over to the technique of sentential (propositional) calculus, which we will use as an appendix to T-theory.

4. Using the Technique of Propositional Calculus in Problems of Value-Based Management

The study of the formal T-theory is based on two classes of statements:

1) theorems;
2) meta theorems.

In the first case, theorems are just statements of the theory proper, with respect to which, purely formal objects are preset.

In the second case, statements on the properties of its theorems, proofs etc. are made; the statements are created in the language being external with respect to the theory.

In both cases, the propositional calculus consists of four elements:

1) the alphabet of the propositional calculus $A,\ B,\ C,\ ...$, logical operators $\vee,\ \wedge,\ \neg,\ \rightarrow$ and brackets $(\ ,\ )$;
2) formulas;
3) two systems of specific axioms I and II [36];
4) rules of inference (the substitution rule and the rewriting rule).

Two important notes should be made at this point.

First, the formulas are used not as a means of function representation but as a statement basis created from elementary statements by virtue of logical operations,

Secondly, the availability of the axiom system I is more consistent, since all the tools are fixed and back-end. The second system of axioms (II) more strictly corresponds to traditional mathematical interpretation of formulas.

The formula $F_j^{k_j}$ of propositional calculus is meaningfully interpreted as a compound statement, the truth of which depends on the truth of elementary statements inherent in it.

Let us assume that the formula $F_j^{k_j}\left(U_{j1},\ ...,\ U_{jm}\right)$ is set, as well as the distribution of truth of elementary statements included into the formula. We have to calculate the logical function f_j on the set $\left(\sigma_{j1}\ ,...,\ \sigma_{jm}\right)$, wherein $\sigma_{jk} = 1$, if U_{jk} is true, and $\sigma_{jk} = 0$, if U_{jk} is false.

With respect to elementary statements $U_{j1}, \ ..., \ U_{jm}$ the following distribution of truth is set:

$$U_{jk}^{\sigma_{jk}} = \begin{cases} U_{jk}, & если \ \ \sigma_{jk} = 1; \\ \neg U_{jk}, & если \ \ \sigma_{jk} = 0. \end{cases}$$

Theorem: Let the formula $\aleph(U_1, \ ...,U_n)$ determine the logical function f from m variables. Then, if $f(\sigma_1, \ ,..., \ \sigma_m) = \sigma$, the propositional calculus will have $U_1^{\sigma_1}, \ ..., \ U_m^{\sigma_m} \big| \ -\aleph^{\sigma}$.

The Gothic character $\aleph$ characterizes meta-formula or a scheme of formulas. The scheme of formulas $\aleph$ denotes the set of all calculation formulas obtained if its meta-variables are substituted by calculation formulas.

Let us assume that $\aleph(U_1, \ U_2, \ U_3 \ \ U_4)$ describes the expression for the value-based theory $T_C < T_S < T_P < T_V$ (the modified golden rule of economics [25, 26]).

For instance, if we substitute $\aleph$ for $(((U_1 \to U_2) \to U_3) \to U_4)$, we shall obtain the formula $\aleph(U_1, \ U_2, \ U_3 \ \ U_4) = (((U_1 \to U_2) \to U_3) \to U_4)$. Such a formula, with respect to the value set (1, 1, 0, 1), defines the logical function $f(1, \ 1, \ 0, \ 1) = 0$ equal to zero.

The terms of propositional calculus with respect to T-formal theory can be quite easily characterized in terms of the truth.

First, any theorem of propositional calculus is an identically true proposition.

Secondly, any identically true formula is a theorem of propositional calculus.

When operating logical functions, we may say from the logical standpoint that we deal with binary (dyadic) objects which are considered as true or false statements. Operating with such objects, we do not apply to their logical content. Instead, we have to manage by using set-theoretic interpretation, considering objects as functions on binary vectors of the function domain of Boolean functions, - and we have a fairly simple structure.

When investigating logical interpretation of objects, it is necessary to rely already not on specific applications of one's own, but on the predicate calculus technique instead.

5. Predicate Calculus Technique

The knowledge of predicate (quantificational) logic, which, as a special case, includes propositional logic as well, is that the predicate logic forms the basis of a logical language. By virtue of predicate logic, one manages to form and precisely investigate the main methods of construction of formal theories.

Predicate logic is a basis for constructing well-developed logical languages and formal systems.

We will understand the expression $P(x_1, \ ..., \ x_n)$, wherein $x_1, \ ..., \ x_n$ are variables, as a variable statement, the truth of which is determined by substitution of M for $x_1, \ ..., \ x_n$. At the same time, $x_1, \ ..., \ x_n$ are non-logical variables.

Predicates are statements wherein some arguments can be placed.

Predicate calculus claims for the availability of four components:

1) the alphabet;
2) formulas;
3) axioms of predicate calculus:
   - axioms of propositional calculus (any of the systems of axioms I and II);
   - two predicate axioms:
     i. P1. $\forall x F(x) \to F(y)$;
     ii. P2. $F(y) \to \exists x F(x)$.
4) inference rules:
   - the conclusion (Modus ponens): $\dfrac{\Im, \ \Im \to \aleph}{\aleph}$;
   - generalization ($\forall$): $\dfrac{F \to P(x)}{F \to \forall x P(x)}$;
   - $\exists$ – introduction: $\dfrac{G(x) \to F}{\exists x G(x) \to F}$.

The availability of new axioms (P1 and P2) has allowed us to quit the axiom systems I and II. That took place due to the fact that a verbal limitation of the occurrence of variables is given complete with the axioms P1 and P2. In other words, not a single occurrence of x is within the scope of y. Moreover, we have the result of substitution of term y into $F(x)$ instead of all the free occurrences x; besides, all variables y should be free $F(y)$.

In terms of language of management, this means that the external environment condition is changed after any decision is taken, and at the next moment after the decision-making the general concept should be extended, the new condition environment should be tested, descriptions of specific actions should be corrected, and some new objective instruments ensuring the performance of those actions, should be developed.

The conclusion made confirms the expedience of studying efficiency of reference activity within the framework of T value-based theory, wherein the introduction of a new axiom claims for range expansion of formal system at the expense of studying non-system factors under new conditions. Let us assume that, in process of investigation of sensitivity of key value factors, a certain proposition concerning manager's behaviour, us formulated: "not succumbing to pressure from the group under the extreme-scale circumstances, the manager is operating efficiently". Such a definition can be reduced to the kind as follows: $\forall x(W(x,\ g,\ c)\exists M(x))$, wherein W is the relation "not succumbing", M – the relation "operating efficiently", x – a person, g – a group, c – a circumstance. Similar steps are taken when advancing other propositions, too.

In the general case, when studying new situations, a detailed description of a new situation is needed apart from formula, which will eventually affect both the description of initial objects and documentation of actions to be taken when the enterprise is functioning under new circumstances. As an illustration, it should be pointed out that the examined statement of the problem will essentially change if one is required to start description of an event which would bring about an increase in the enterprise value, preserving its significance at competitive market focused on a loyal player. [37].

Thus, the predicate calculus technique allows one – despite the accepted prerequisite of non-interference into substantial interpretation of logical operations occurring between subjects of investigation – to make imperceptibly an actual plunge into the conceptual problem by virtue on objective means, – disclosing the Deming paradox to a certain extent: "How can one improve each process, not interfering with the stable process?" Apart from that, the attitude towards axioms changes fundamentally so far as the predicate calculus technique is mastered. Axioms cease to be expressions of calculus; at the same time, jointly with a specific verbal text supplied complete, they turn into a meta description of a set of formulas being schemes of axioms. As a result, awkwardness is eliminated, and studying of the formal T-theory in terms of the truth and provability is simplified.

First, any provable formula of predicate calculus is identically true.

Secondly, any generally-valid predicate letter formula in predicate calculus is provable.

It should be noted that applied predicate calculus (note that this refers to first-order theories) are characterized by the fact that purely logic axioms contained in them are frequently supplemented by axioms of its own, wherein, as a rule, some specific predicate letters and predicative constants take part.

The bulk of predicate calculus contains equality predicate and some axioms defining it:

E1. $\forall x(x = x)$ – specific axiom

E2. $(x = y) \to (F(x,x) \to F(x,y))$ – axiom scheme.

The "axiom scheme"-based approach implies that general-logic axiom schemes are described by formulas in meta variables; proper axioms of applied calculations can also be set either by (AI) schemes or by specific axioms, i.e., by formulas of calculation proper (E1).

At any rate, proper axioms contain hold fixed functional and predicate letters, which are thereby assigned some properties that distinguish them from other letters of calculus.

6. Addition of Informal Sense at a Constructive Level

Reducing axioms to the level of meta-descriptions of a set of formulas allows one to add some informal sense to the formal T-theory, and to pass over to the meta-theory of logical investigations.

Meta-theories of logical investigations should be interpreted as studying their general properties and the correspondence of those properties to purposes for the sake of which the study was organized.

The value of the formal, value-oriented T-theory, as the value of any formal theory, is determined by its capability of describing some objects and the ties between them. Therefore, this section will focus on the adequacy of the formal T-theory.

The problem of adequacy of the formal theory and the investigations describing its subject is considered as a mathematical problem of correspondence between a meaningfully-built theory, considered as a set of objects with operations and relations, and a set of statements on that theory, – developed as a formal calculus.

Interpretation of a formal theory consists of a set M and a single-valued transformation assigning $n-$ place relation on M to each predicate group P_j^n, $n-$ place operation on M – to each functional letter f_j^n, and the element M – to each object constant. The set M considered the underlying set of the algebraic system, is the interpretation domain.

The interpretation will be a model of the formal T-theory if it's a model of a set of all T-theorems, i.e., if any formula provable in T-theory is true in a specific interpretation.

If any open formula $F_j^{k_j}$ with a preset number of attributes k_j where $j=1,\ ...,\ n$ (which, strictly speaking, is not a statement) is provable in the formal T-theory, – then, within the model of the formal T-theory, all the statements derived from $F_j^{k_j}$ by all possible constant propagations to the place of unrestricted (free) variables of the formula $F_j^{k_j}$ – should be true, – and, consequently, the statement $\forall x_{j1}\ ...\ \forall x_{jn}\ F_j^{k_j}$ wherein $x_{j1},\ ...,\ x_{jn}$ are free variable formulas $F_j^{k_j}$ – should be true as well.

It should be noted that no sense is put into calculus symbols (even the most habitual ones) until explicit interpretation is introduced (that is exactly the essence of the formal approach).

However, neither does the interpretation introduced pertain to the number of tools of the calculus proper: it allows one to give meaning to calculus formulas, but dos not take part in formal inference of theorems.

Normally formal properties of calculus proper, of its formulas, and the properties of formal manipulations on the formulas are spoken of as calculus syntax defined by constructive means.

The calculus properties described in terms of interpretation of calculus are means of the calculus semantics), for example, description on the basis of meta theorems).

T-theory is fit for describing those sets that are its models.

A model of T-theory exists if and only if T is semantically consistent.

A theory is semantically consistent if neither of its theorems is consistent, i.e. false, in any interpretation.

T-theory is formally consistent if no such formula $F_j^{k_j}$ exists that $F_j^{k_j}$ and $\neg F_j^{k_j}$ would be theorems of T-theory, i.e., the formula and its negation is disprovable into T.

Similar definitions can be also formulated for an arbitrary set of formulas.

If a set of formulas is semantically consistent, it is formally consistent.

With respect to any consistent set of formulas, its model can be constructed.

As a result, we have the scheme as follows:

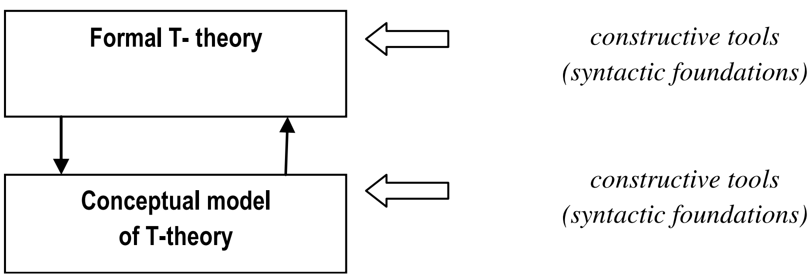

Figure 2. Correspondence between formal theory of value-based management and its model

Therefore, formal consistency notion turns out to be equivalent to semantic consistency notion more habitual in mathematics; however, it is formulated in syntactic terms and is more reliable from the constructive standpoint.

The approach considered above extends the concept of value-based management when evaluating the efficiency of reference activity, allowing one to pass over to the conceptual model of T-theory.

7. Disclosure of Conceptual Sense

We should start the further investigation of the conceptual sense of value-based theory from posing the questions like "Does the formal theory correspond in this case to the goals pursued by the construction of the model? Is the theory adequate?''

Since the formal theory model does not disclose any conceptual sense, we should pass over to the conceptual theory C and consider the scheme presented on Figure 3 below.

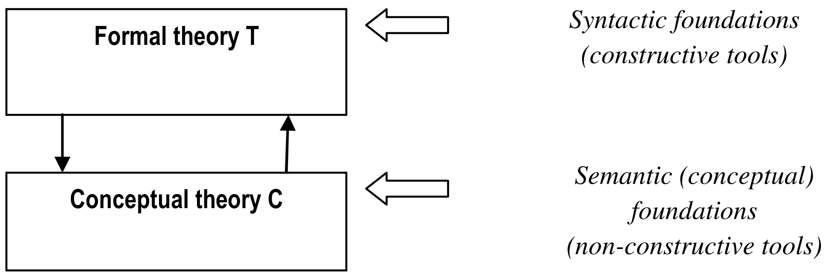

Figure 3. Correspondence between formal theory and conceptual theory of value-based management

On the one hand, we have the formal T-theory constituting a set of expressions derived from axioms of T-theory by virtue of inference rules of T-theory. On the other hand, a conceptual C – theory, formulated in semantic terms, takes place – i.e., it constitutes true statements concerning a certain algebraic system.

A necessary attribute of formalization is the condition implying C being a part of T-theory, i.e. mapping into a true statement from C should exist.

An exhaustive formalization of C will be such a T-theory with respect to which reciprocal correspondence is performed: each true statement of C-theory is mapped into a certain theorem of T-theory.

The T-theory possessing the property of exhaustive formalization is complete in reference to C, and sometimes, it is adequate as well.

If one manages to construct a consistent and complete formal T-theory for the conceptual (semantic) C-theory – C will be an axiomatizable or formalizable theory.

The formal T-theory is decidable if there an algorithm exists, which determines for any language formula, whether or not the theory is the T-theorem.

In summary, the following can be stated in terms of theory of algorithms:

1) a set of all the true statements of propositional logic is enumerable and solvable;
2) a set of all the true statements of predicate (quantificational) logic is enumerable but not solvable;
3) a set of all the true statements of arithmetic is not enumerable.

Taking into account the first Godel's incompleteness theorem, there is no adequate formalizations for a value-based management theory which is rich enough mathematically, since any incomplete T-theory can be expanded by adding to it – as a new axiom – a formula being true but not derivable into T.

According to the second Godel's incompleteness theorem, it is not possible to investigate any meta properties of a theory by means of the formal theory proper.

The informal theory C (or T-metatheory) should be richer than T, and only then one can approach provability: as a preliminary, the consistency of T-theory. Within the framework of value-based management, the C-theory should have some tools of identification of extreme-scale circumstances that may occur within the T-theory.

To that end, one should expand the concept of a formal theory at the expense of looking for fragments of incomplete formalization and tying them subsequently, – or, developing a stronger formal theory which, even if its incomplete, can contain the entire original theory.

In both cases, improvement of formal systems takes place.

8. Improvement of Formal Systems

The destination of formal systems is aimed at their continuous improvement, since such systems are created for a more precise substantiation of formal theory development methods. Based on the same principles – an initial axiom set, derivability rules and notions – one can describe not only sets of expressions interpreted as statements, but also enumerable sets of objects of an arbitrary form.

The object of study of the general theory of formal systems is impossible properties of specific systems. In terms of the value-based management theory, key factors of productivity are studied [38].

Nevertheless, when investigating possibilities of objects studied in a specific theory, the formal system gives an answer to the question "Which sets are generated by formal systems?" Since the tools of formal systems are axioms and inference rules – formal systems are used to set constructive objects when constructing a system of basic notions, formalizing ideas of efficiency and constructivity. To that end, a concept created by R. Post is used, which is based on the notions of a formal (rather a canonical) system and an enumerable set defined as a set of theorems of a formal system [39].

Canonical formal systems are determined by the alphabet of their own: $A = \{a_1, \ ..., \ a_m\}$ – the alphabet of constants; $X = \{x_1, \ ..., \ x_n\}$ – variable alphabet; a finite set of axioms and a finite set of rules that can be presented as $\gamma_1, \ ..., \ \gamma_k \Rightarrow \delta$ and that are called productions (as usual, $\gamma_1, \ ..., \ \gamma_k$ are called premises and δ – consequence).

Axioms as well as premises and consequences represent words in the alphabet $A \cup X$.

It terms of canonical systems, any enumerable sets can be described.

Although, the used definition of a canonical system (in particular, kind of its productions) is quite loose: using the production can hardly be called an elementary step (although the property of applicability of production is solvable).

Therefore, a problem of normalization of canonical systems comes to the fore – that is to say, the problem of imparting a simpler ("normal") form to them. A canonical system is called normal if it has one axiom, while all of its productions are of the form $\alpha x \to x\beta$.

Let's mention the Post's normal form theorem: for any canonical system CS with the alphabet A , there exists a normal canonical system above A , equivalent to CS (i.e., a set of NS theorems above A and a set of CS theorems coincide).

Normal canonical systems belong to the class of abstract formal systems, wherein, unlike logical calculus, the notion of formula is not singled out.

Their objects are arbitrary words in functional alphabet.

Formal systems FS are defined by:

- Alphabet A ;
- Decidable set $A^* \subseteq A$, the elements of which are called axioms;
- The finite set of computational relations $R_i(\alpha_1, \ ..., \ \alpha_n, \ \beta)$ on the alphabet A , called inference rules; the word β is called a derivation from $\alpha_1, \ ..., \ \alpha_n$ according to the rule R_i .

A normal canonical system above alphabet A can be represented as a graph with one highlighted vertex **–** axiom**;** the other graph nodes are highlighted by words in A-theorems, with the ribs of the graph being applied production, and ways from the highlighted production to the given one characterize possible conclusions for this word.

Set of words in A generated by the system – is the set of all the graph nodes marked by words.

The corresponding graph represents a chain depicting a computation process; an axiom within such a graph is just initial data of a specific algorithm which is a formal system of a special determined kind; a peculiar feature about that system is that no more than one production is applicable therein to each theorem.

In this case, we have two key points which should be not so much highlighted from algorithmic or formal-system appurtenance, as supplemented. The main emphasis of the "algorithmic" concept is in its determinism. That's why it is natural and convenient when describing computational processes and tools. The main emphasis of the "formally-system" concept is its complexity of constructive description of sets.

Schematically, supplementing of the formal-system concept with algorithmic concept is presented on Figure 4.

The canonical formal T-theory, supplemented with the tools of the formal-system concept, acquires the status of T'-theory built by virtue of constructive-conceptual foundations which, moreover, are preset in terms of definitions of a natural language. The supplemented theory of a formally-conceptual T'-type changes only if situations exceeding a set level of losses in value, equivalent to an extremely large-scale circumstance (for instance, type II error), are recorded in the course of reference activity. Such situations characterize a formal system overrun, and they claim for formulation of a new axiom. Otherwise, no interference with the management system is required, since we have a complete meaningful guideline to drive the process – on a preset multitude of objects with a definite efficiency level of reference activity.

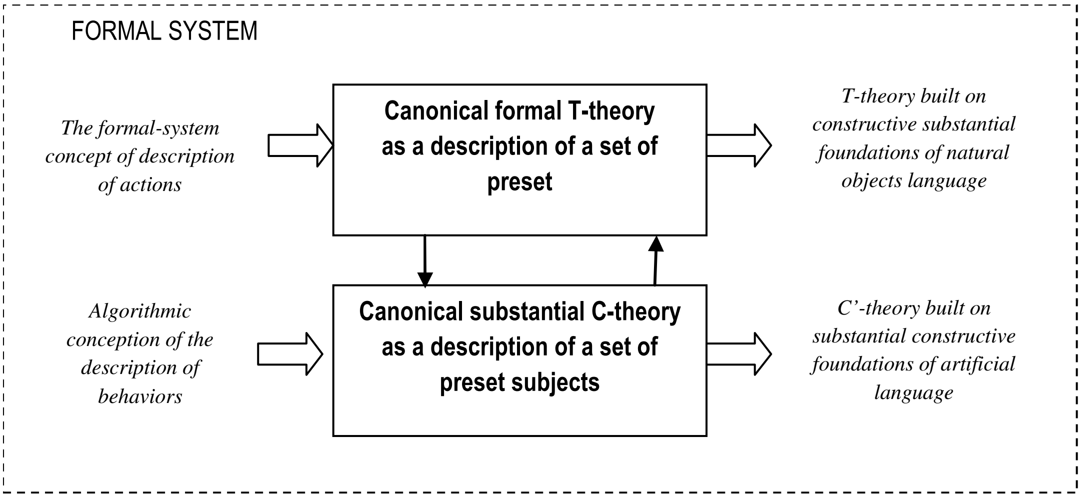

Figure 4. Scheme of formalization of the value-based management theory

The canonical content C-theory, supplemented with tools of algorithmic concept, forms, in its turn, a new C'-theory built by virtue of conceptual-constructive foundations based on rules of rules of artificial language. A content-formal type C' theory should be methodically better-off than T-theory, since, when a reference process is described, one should take into account a multiple safety factor in terms of the management system's response to an occurrence of extremely large-scale circumstances. In axiomatic approach, the axiom set of C' theory is much wider than the one in T-theory. When setting the reference process standards, the reference process efficiency is evaluated in terms of cost (monetary) equivalent. As a result, a detailed description of reference activity is formed in terms of a description of a set of objects at the level of individual operations. Such a description, completed with objective diagnostic tools, is a guide for action worked out with consideration for preset conditions of the formal system state.

In terms of predicate calculus (in terms of an artificial language), the usage of quantifiers in predicate axioms P1 and P2 when describing an initial set of objects, seemingly limiting the interpretation domain when setting logical operations, actually allows one to obtain a theory which (in terms of a natural language) meets the objectives for the sake of which the models of that theory were constructed.

9. Formal Systems Application

The formally content T-theory receives an expanded graph of initial axioms as an initial graph (the totality of axioms put forward). Originally, nodes of the graph are procedure names which should be debugged. In terms of algorithms, the overlying graph nodes, with respect to the underlying graph nodes, characterize suspension modules, while the graph nodes are in essence blank modules. In process of debugging, within the framework of the content-formal C'-theory and in compliance with the rules of structured modular and stepwise detailed design, a debugged algorithm is worked out (which in this case is a totality of interrelated proved theorems and productions), the effect of which has been checked with consideration for a behaviour under extreme large-scale circumstances.

In other words, within the framework of the formally content T'-theory to provide for reference activity, when efficiency issues are studied, – an application from the content-formal C' theory (which may be deemed a request for self-service) is made to investigation of an adequate reference process at efficiency level. The content-formal C'-theory, presented in the form of a debugged algorithm of a reference process, fills in the established form of the canonical formal T-theory of a certain reference activity with the content of transformed reference process (when passing over from C-theory to C'-theory), – which essentially enriches the formal-content T'-theory. Complete with C'-theory including the debugged algorithm, objective means of diagnostics, and efficiency standards, – T'-theory received a description of reference activity, being a guide to action when evaluating its efficiency.

Thereby, we have managed to make the concept of a reliable enterprise design (see Fig. 1) more precise in terms of a formal system, – which makes it relevant to present the diagram shown on Figure 5.

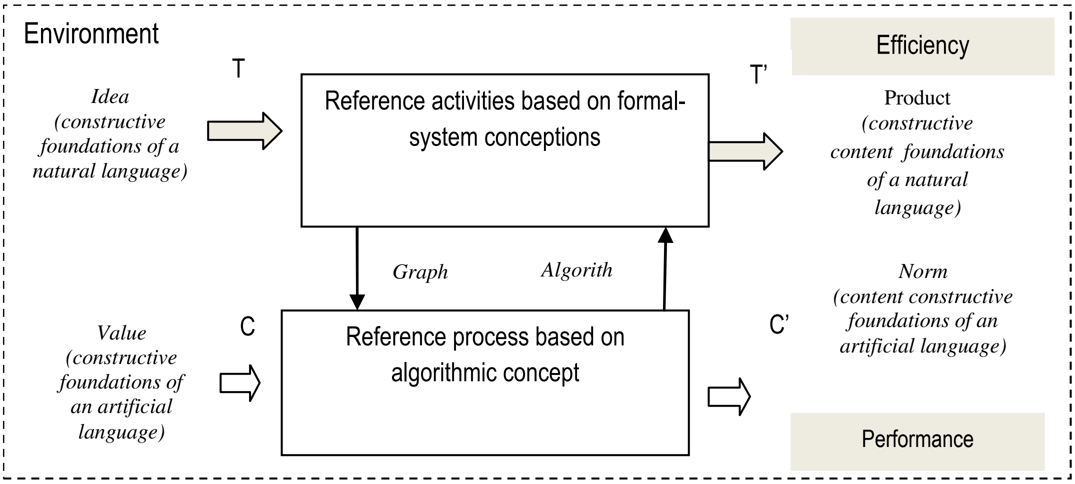

Figure 5. Scheme of a reliable enterprise in the context of a formal system

Therefore, conceptual representation of the value-based theory in terms of a formal system corresponds to the provisions of the technique of a reliable enterprise design.

All of that allows one to make crucially new generalizations not only concerning harmonization of reference activities and reference process but enabling one to obtain some adjustments fit for tying constructive and content foundations of a natural language due to transforming the idea into the end product which will bring about a substantiated fundamental change.

That's exactly the management phenomenon whereby technical art elements are turned into those of management science built on principles of scientific rationale and description of practical activity. The management science, synchronizing the rate of development of the formal and the content theories, fills practical formulas of intuitionistic logic with a new content (it should be noted that the content is free from philosophic prerequisites of intuitionism). Each action formula should be considered not as an assertion but as a requirement serving as a basis for building an object subject to particular preset conditions. If the enterprise cost $PV_{project}$ allows one to time *t*-idea at the efficiency level $PV_{project}\left\{Ef \Rightarrow FV^{(1)}; WACC^{(1)}; IRR^{(1)}\right\}_t$ and the result set at the same moment as an efficiency parameter $PV_{project}\left\{Pf \Rightarrow FV^{(2)}; WACC^{(2)}; IRR^{(2)}\right\}_t$, then, as a measure of reliability of an organizational structure, we have the ratio of the minimum enterprise value based on efficiency, or the cost based on effectiveness, against the maximum value of those variables: $Ros_t = \dfrac{\min\left(PV_{project}\{Ef\}_t;\ PV_{project}\{Pf\}_t\right)}{\max\left(PV_{project}\{Ef\}_t;\ PV_{proect}\{Pf\}_t\right)}$.

This measure is a deductibility formula obtained according to the following rule: $PV_{project} : \dfrac{A_1^*,\ ...,\ A_5^*}{Ros}$,

wherein $A_1^*,\ ...,\ A_5^*$ represents a set of axioms suggested for T'- theory (See Table 4).

Table 4. Axioms of a reliable enterprise design [13]

No	Designation	Content
Axiom 1	A_1	No ordered couples exist in process of management
Axiom 2	A_2	Ensuring uniformity of reference activity and reference process
Axiom 3	A_3	Organization of management structure starts after the management principles are accepted
Axiom 4	A_4	Ensuring reasonable conformity
Axiom 5	A_5	Negation of principle of excluded middle [40]

The design axioms suggested above are proper (eigen) axioms based on which, one can control measurements in a new fashion even if measuring their accuracy is impossible. Based on such axioms, reliable information is prepared in the process of a more precise definition of concepts and reproduction of properties. Such information is obtained in process of a straightforward design of a pattern due to combining data of two kinds: rigid data (having contents; serving as a base for description and not explanation) and soft data (subjective and indefinite, serving for explanation lying behind rigid facts). The axioms of a reliable enterprise design allow one to unite sequential totalities of different-scale events, forming a unique organization, in the form of synthesis.

Problems of management performed by virtue of proper (eigen) axioms formulated according to the provisions of formal systems, have a keystone idea of continuous development of a crucially new model (as opposed to the idea of using the existing model). Such a prerequisite implies that formalization is used not as a design method but as a method of thinking, as a language, as a means of formulation, organization, and tying of concepts. Mastering means of formalization at such a level enhances the importance of precise formulations and works out a habit of temporary abandonment of habitual concepts if they hamper understanding of the essence of activity.

10. Conclusions

The approach considered above helps one to understand the problems arising in process of creating the structure of an enterprise. Such problems are deliberately separated from operational propositions, giving one an opportunity of getting to reproduction of activity through a direct process, synchronizing it with the available knowledge of the inverse process. Eventually, organization being created by virtue of means of formalization examined is a substance allowing one to adjust the description of a set of objects to reality. The usage of such tools provides for a solution of practical problems of management by virtue of management science which promotes mastering of eigen unconscious methodology of enterprise existence and development. This is achieved at the expense of synchronizing the growth rate of the formal and the content theory.

The results of the value-based management theory investigation, performed in the context of formal systems, allowed one to set up its correspondence to requirements formulated within the framework of a pragmatic model used in process of design of a reliable enterprise.

By virtue of the methodology suggested, we have managed not only to achieve the objective posed but to solve a number of conceptual problems as well; namely, based on strong evidence and obvious assertions, some necessary rules of management have been singled out and some manageability criteria have been developed. All of that imparts a meaningful sense to management science at the expense of the definition of well-formed expressions forming the theory language for the description of a set of objects that constitute reference activity. The combination of content and constructive foundations aids one in the formation of skills of recognition of complicated and simple circumstances; moreover, it aids in the formation of skills of understanding ties between seemingly far-away ideas and concepts, as well as enhancing the importance of accuracy of formulations.

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EVALUATION OF FAIR MARKET PRICE OF RESOURCES IN OIL AND GAS INDUSTRY USING FUZZY SETS AND LOGICS

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Managing the complexity and profit of major projects in today's oil and gas sphere has never been more critical. Against the backdrop of a decline in both global economic conditions and corporate revenues, stakeholders are demanding improved return on investment (ROI), reduced risk and exposure and greater transparency. Since capital construction projects in the upstream oil and gas industry comprise a significant percentage of company spend, there must be a particular focus on predictability, transparency and reliability, including estimation of profit, controlling and reducing the costs associated with these projects. The best opportunity to make a positive impact on the life cycle of capital project in this industry is during early planning, even before the capital outlay occurs. Emphasis should be placed on budget control, approved corporate budget changes and project management internal budget transfers. As the prices of oil and gas fluctuate every day this is the most difficult part of budget control, because even slight changes in the value has a huge impact on overall financial situation of project. That's why it will be very convenient to use Fuzzy Logic methodology of Soft Computing to make certain calculations in order to estimate the fair price of resources and remove the uncertainty of non clear boundaries of oil price.

Keywords: oil and gas industry, Fuzzy Sets and Logic, oil price, gas price, FRIL, intellectual system, management of resource effectiveness

1. Introduction

The novelty of the work is in development of an intelligent system to assess the factors in the formation of market prices for oil and gas for the performance management of project using the Soft Computing methods of calculation and the theory of Fuzzy Sets.

This application provides a solution to the problem of assessing profit project, representing the price of oil in the form of fuzzy sets. These types of applications designed for project managers in the oil and gas industry with a view to future business decision-making based on an evaluation of the project profits. In addition, all investors and financial institutions in this sector may be interested in using this tool.

To determine the optimal price of oil it is advisable to apply the theory of Fuzzy Sets and Logic, which is one of the fastest developing methodologies of Soft Computing, and a system of "IF-THEN" rules to establish relationships between parameters.

2. The Theory of Fuzzy Sets

The research on the theory of Fuzzy Sets began in the last century by Japanese scientists Mamdani, E., and Assilian, S., 1975. The theory of Linguistic Variable has been introduced by L. A. Zadeh in 1965 [2] and now has wide practical application. The theory of Fuzzy Sets has been used successfully in the development of automated systems, forecasting systems, expert systems.

3. Description of the Project

The main idea of the project is to consider the two parameters (the price of oil grade Brent dtd. And market differential), as well as the variation of dollars in Kazakh tenge (since the price of oil depends on the change in the dollar) as fuzzy sets, since these parameters are not are constant and are updated frequently (daily).

Concerning all the conditions for the formation of fuzzy sets the next sets can be identified as the universal sets of data based on statistical information:

UX1= [80,140] – for the price of Brent dtd;
UX2= [-5, 5] – for the value of market differential;
UX3= [145,148] – the value of the dollar in tenge;
UY = [50,160] – the final price of oil.

Approximate values of the boundaries of the sets are taken from the statistical values of these parameters for the previous year (see Figure 1) [3]. Thus, the system has three inputs and one output parameter.

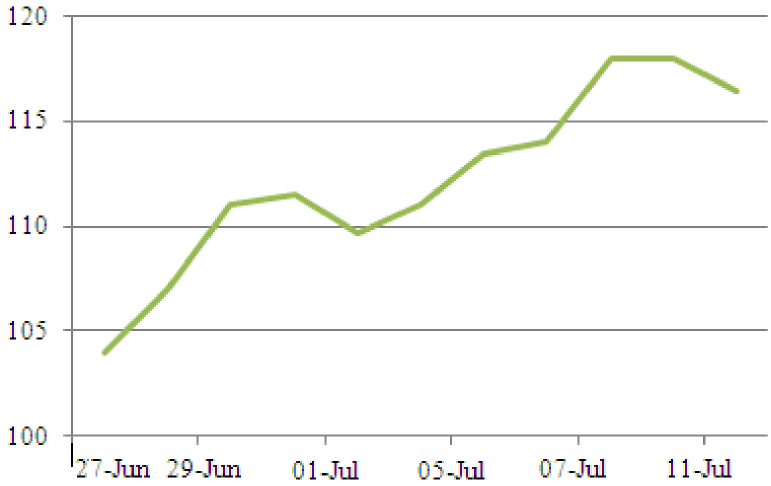

Figure 1. The price for Brent dtd. Oil. Source Platts

In addition, the following have been identified for the input fuzzy sets X1 and X2 and the output set Y with the values of the degree of membership.

Fuzzy sets on X1 (for the price of Brent dtd.):

‘less than usual’ = {1/80, 0.8/90, 0.7/100, 0.5/110, 0.2/113, 0.1/115, 0/118, 0/120, 0/130, 0/140}
‘more than usual’ = {0/80, 0/90, 0/100, 0/110,0.2/113,0.4/115,0.5/118,0.7/120,0.9/130, 1/140}

Fuzzy sets on the X2 (for the value of the market differential):

‘significantly high’={1/-5, 0.8/-4, 0.5/-3, 0.2/-2, 0/-1, 0/0, 0.1/0.1, 0.2/1, 0.4/2, 0.6/3, 0.9/4, 1/5}
‘significantly low’={0/-5, 0.2/-4, 0.4/-3,0.7/-2, 0.8/-1, 1/0, 0.9/0.1, 0.8/1, 0.6/2, 0.3/3, 0.1/4, 0/5}

Fuzzy sets on the X3 (for the value of the dollar):

‘small medium’ = {1/145, 0.7/145.5, 0.5/146, 0.2/146.5, 0/147, 0/147.5, 0/148}
‘big medium’ = {0/145, 0/145.5, 0/146, 0.3/146.5, 0.5/147, 0.8/147.5, 1/148}

Fuzzy sets on Y (for the final value of the oil price):

‘cheap’={1/50, 0.9/60, 0.8/70, 0.7/80, 0.6/90, 0.4/100, 0.2/110,0/115, 0/120,0/140,0/160}
‘normal’={0/50, 0/60, 0.1/70, 0.3/80, 0.5/90, 0.7/100, 0.9/110, 1/115, 0.5/120, 0/140,0/160}
‘expensive’={0/50, 0/60, 0/70, 0/80, 0/90, 0/100,0/110, 0/115, 0.7/120, 0.9/140, 1/160}

8 "IF-THEN" rules can be determined in the system taking into account a set of dollar exchange rate:
RULE 1: IF X1 ‘less than usual’ and X2 is ‘significantly low’ and X3 is ‘small medium’, then Y is ‘cheap’
RULE 2: IF X1 ‘less than usual’ and X2 is ‘significantly low’ and X3 is ‘big medium’, then Y is ‘optimal’
RULE 3: If X1 is ‘less than usual’ and X2 is ‘significantly high’ and X3 is ‘small medium’, then Y is ‘optimal’
RULE 4: If X1 is ‘less than usual’ and X2 is ‘significantly high’ and X3 is ‘big medium’, then Y is ‘optimal’
RULE 5: If X1 is ‘more than usual’ and X2 is ‘significantly low’ and X3 is ‘small medium’, then Y is ‘optimal’
RULE 6: If X1 is ‘more than usual’ and X2 is ‘significantly low’ and X3 is ‘big medium’, then Y is ‘optimal’

RULE 7: If X1 is 'more than usual' and X2 is 'significantly high' and X3 is 'small medium', then Y is 'optimal'
RULE 8: IF X1 is 'more than usual' and X2 is 'significantly high' and X3 is 'big medium', then Y is an "expensive".

The usage of special language and programming environment FRIL (Fuzzy Relational Inference Language) allows calculating the number of cases.

4. Development Technologies

To develop an application to perform calculations FRIL language of inference was used, a programming environment of which was installed on a virtual machine Unix – Ubuntu. FRIL is a programming language designed for the first order predicate calculus. FRIL was originally stood for "Fuzzy Relational Inference Language", which was the predecessor of the current language FRIL, and was developed in the late 1970s after the work of Jim Baldwin on fuzzy relations [4], [5].

5. Analysis of Results

Let us analyse the results. When the price of Brent dtd. equals to 120 (which belongs to the set 'more than usual'), a market differential CIF equals to -3, and the dollar value equals to 146.5, the application displays the defuzzyfied value by the eight rules, which is equal to 113.177, and it belongs to the set 'normal' / 'optimal'. If you calculate the price of the resource according to the formula given in the analysis of the agency RFCA [6], we can only use the first two parameters: the price of Brent dtd. and the value of the market differential CIF. The result is 120 - 3 = 117. However, using the methodology of Soft Computing and the theory of fuzzy sets allows us to more accurately estimate the price of the resource, determining the starting point in pricing in order to optimise the market. Consideration of the situation on the market, factors influencing the pricing of oil, as well as their changes over time can easily be varied and used in the application of the theory of fuzzy logic.
The use of fuzzy set theory in predicting the price of the resource in oil and gas industry provides an opportunity to depart from the strict and inflexible principles of calculation in the model of crisp set (binary number). For example, in the case of a crisp or binary set, we can take only three pairs of specific values for Brent dtd. oil prices and market differential, and to calculate the estimation in three cases: the worst, average, and the best. The difference between these three results is significant, that, in the future can reflect in the calculation of profit and cost of the overall project. Moreover, this calculation can lead to large losses in the project budget (approximately millions of dollars).
With the help of fuzzy sets we can take into account the change of prices over time, in other words, statistical or historical fluctuations of prices. Another important value of fuzzy sets is the ability to manage uncertainty. This means that we can more accurately determine (based on statistics), which digits, that represent the price of oil, can be called 'normal' or 'above' / 'below' it and with what degree of membership to this set.

6. Conclusions

In conclusion, the fuzzy sets and logic can be successfully applied to estimate the profit of the project by assuming some parameters as fuzzy sets, building these sets and applying the foundations of fuzzy logic to them in order to reduce uncertainty. The application can be easily configured to calculate the price of gas and other mineral resources.
This paper shows a mechanism for calculating the price of oil, however, the same tool, taking into account various additional parameters, such as the consumption of petroleum and petroleum products in a specific period of time, the amount of energy resource available on the market, conditions of delivery, the number of traders, the quality of exported oil products, the stability of production and supplies, the cost of oil production in a particular region, the rules of legislative regulation, the presence / absence of export taxes on energy and the amount of insurance payments, etc., can give a more general picture of the costs of oil and gas projects.

The developed application not only allows making a transparent resource assessment and costing of the project, but also is a convenient tool for decision making in the economic situation.

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Appendix

Source code

```
%% oil-price.frl
%% NOTE: we use FRIL method of inference
%% (different from Mamudani, Sugeno,etc.)
% estimate the price of oil depending on Brent dtd., market differential, and dollar variation
% INPUTS: price of Brent, market differential, value of dollar
% OUTPUT: oil price

%% universe of diccourse
set (dom-brent 80 140)
set (dom-market_dif -5 5)
set (dom-dollar 145 148)
set (dom-oil_price 50 160)
%% fuzzy sets on Brent dtd.
(less_than_usual [80:1 90:0.8 100:0.7 110:0.5 113:0.2 115:0.1 118:0 120:0 130:0 140:0] dom-brent)
(more_than_usual [80:0 90:0 100:0 110:0 113:0.2 115:0.4 118:0.5 120:0.7 130:0.9 140:1] dom-brent)

%% fuzzy sets on market differential
(significantly_high [-5:1 -4:0.8 -3:0.5 -2:0.2 -1:0 0:0 0.1:0.1 1:0.2 2:0.4 3:0.6 4:0.9 5:1] dom-market_dif)
(significantly_low [-5:0 -4:0.2 -3:0.4 -2:0.7 -1:0.8 0:1 0.1:0.9 1:0.8 2:0.6 3:0.3 4:0.1 5:0 ] dom-market_dif)

%% fuzzy sets on dollar
(small_avg [145:1 145.5:0.7 146:0.5 146.5:0.2 147:0 147.5:0 148:0] dom-dollar)
(big_avg [145:0 145.5:0 146:0 146.5:0.3 147:0.5 147.5:0.8 148:1] dom-dollar)

%% fuzzy sets on oil price
(cheap [50:1 60:0.9 70:0.8 80:0.7 90:0.6 100:0.4 110:0.2 115:0 120:0 140:0 160:0] dom-oil_price)
(normal [50:0 60:0 70:0.1 80:0.3 90:0.5 100:0.7 110:0.9 115:1 120:0.5 140:0 160:0] dom-oil_price)
(expensive [50:0 60:0 70:0 80:0 90:0 100:0 110:0 115:0 120:0.7 140:0.9 160:1] dom-oil_price)

%% fuzzy rules based on FAM (Fuzzy Associative Matrix)
((price cheap)
    (brent less_than_usual)(market_dif significantly_low)(dollar small_avg))
((price normal)
    (brent less_than_usual)(market_dif significantly_low)(dollar big_avg))
((price normal)
    (brent less_than_usual)(market_dif significantly_high)(dollar small_avg))
((price normal)
    (brent less_than_usual)(market_dif significantly_high)(dollar big_avg))
((price normal)
    (brent more_than_usual)(market_dif significantly_low)(dollar small_avg))
((price normal)
    (brent more_than_usual)(market_dif significantly_low)(dollar big_avg))
((price normal)
    (brent more_than_usual)(market_dif significantly_high)(dollar small_avg))
((price expensive)
    (brent more_than_usual)(market_dif significantly_high)(dollar big_avg))
((simulation-v B D E)
        (addcl ((brent B)))
        (addcl ((market_dif D)))
                (addcl ((dollar E)))
        (p 'Price of Brent:' B ', ' 'Market differetial:' D ', ' 'Value of dollar:' E)(ppp)
        (qsv ((price X)))
        (delcl ((brent B)))
        (delcl ((market_dif D)))
                (delcl ((dollar E))))
%% eof %%
```

Application execution results

Fril >?((simulation-v 120 -3 146.5))
Price of Brent: 120, Market differetial: -3, Value of dollar: 146.5
((price 113.177)) : (1 1)
Fuzzy set [49.9988:0 50:0.895 115:0.895 119.545:0.961818 120:0.958 140:0.916 160:0.916 160.011:0] defuzzifies to 113.177 over sub-domain (60 160)
no (more) solutions
yes

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DECISION-MAKING ON THE BASIS OF GROUP METHODS FOR SYSTEMATISATION AND PROJECT CHOICE

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Exact wording of the decision-making task in space of the relative scale of measurement is provided. The methods and algorithms of solution of the above mentioned task are presented.

Keywords: decision making, project management

1. Initial Concepts and Definitions

1.1. Objects Pairs Comparison

It is not always possible for the objects of the external world to be estimated in an absolute scale of measurement. In such cases the relative scale of measurement is applied.

In a relative scale of measurement the quality of objects is defined and – or is set by comparison of them among themselves. The most elementary operation of objects quality measurement is the pairs' objects comparison on meaning of compared objects parameter.

The comparison of two objects can occur in the following way:

By comparison of parameters meanings (parameters of comparison) of objects: i, j meanings or sizes of the relation of comparison (i R j) are defined.

Definition 1. If the relation R corresponds to the relation of comparison between pair of objects, it refers to as binary (BO).

Thus, BO specifies the comparative relation only of two objects.

1.2. Binary Relations Between Pairs of Objects

Generally it is possible to establish the binary relation between pair of objects, i.e. meaning (size) of the relation doubly.

Variant 1. In the given variant the concrete meaning of comparison parameters (or quality parameters) is not undertaken in attention, only the meaning of these objects parameters from each other at a qualitative level is important.

Thus, qualitative measure or scale of the relation meaning of comparison between objects measurement can be: more, not smaller, less, no more and equal.

Such relation, i.e. meaning of such relation is formally set in the following way:

1) "The object i is better, than object j ", i.e. $i > j$;
2) "The object i is worse, than object j ", i.e. $i < j$;
3) "The object i is not better, than object j ", i.e. $i \leq j$;
4) "The object i is not worse, than object j ", i.e. $i \geq j$;
5) "The object i is equal to object j ", i.e. $i = j$.

It is possible to set these relations also by meaning of an attribute:

$$r_{ij} = \begin{cases} 0, \text{ if } i < j, \text{ i.e. the object i (is worse) than object j,} \\ 1, \text{ if } i \geq j, \text{ i.e. the object i (is (not worse) than object j.} \end{cases}$$

In this case meaning or size of the relation as parameter discretely and equally $r_{ij} \in \{0, 1\}$.

Let's give definition of the binary relation of the given type.

Definition 2. If to the binary relation R corresponds r with elements $r_{ij} \in \{0,1\}$, the relation R refers to as the qualitative or logic binary relation) (LBR).

The meaning of the relation BR can be defined by objective measurement of comparison objects parameters or is by the expert (subjectively), which represents itself as measurer of meaning of the relation.

Variant 2. In the second variant at comparison in attention the exact meaning of comparison (or quality) parameters is undertaken. It is taken into account as far as or on what size (number) the qualities of compared objects differ, i.e. the quantitative meanings of parameters are taken into account.

For example, it is possible to set the binary relations of comparison of two objects in this case in the following way:

1) "The object i is "little" better, than object j". The example, when meaning of the object parameter $x_i = 37$, $x_j = 34$, object i is better on 3 units than object j;
2) "The object i is "in how many" better, than object j". The example, when meaning of the object parameter $x_i = 20$, $x_j = 5$, object i is four times better than object j.

Thus, the measure of meaning of the relation between them is continuous and also it is necessary to set formally and compactly meaning of such relation.

For this purpose it is necessary standardize meaning of comparison parameter. Let's consider that meanings of attributes x_i and x_j of objects $x_i, x_j \in [0,1]$.

Further meanings of the relation we shall define by one of the following ways.

1) Meaning of the binary relation R we shall define by addition of attributes meanings of comparison of compared objects:
$r_{ij}^A = (x_i - x_j + 1) /2$;
2) Meaning of the binary relation R we shall define by multiplication and division of meanings of attributes comparison of compared objects:
$r_{ij}^M = x_i / (x_i - x_j)$.

Let's give definition of the binary relation of the given type.

Definition 3. If to the binary relation R there corresponds a matrix $r = \left\| r_{ij} \right\|$ with elements $r_{ij} \in [0,1]$, the relation R refers to as the numerical or quantitative binary rel111111ation (QBR).

Let's give definitions of types QBR depending on variant of an establishment of their meaning.

Definition 4. If to the relation QBR corresponds r^A, QBR R^A refers to as the additive quantitative binary relation (AQBR).

Definition 5. If to the relation QBR there corresponds a matrix r^M, QBR R^M refers to as the multiplicity quantitative binary relation (MQBR).

The basic properties of QBR are the following.

It is obvious, that the elements of QBR satisfy to the conditions:

$r^{ijA} + r^{jiA} = 1$,
$r^{ijM} + r^{jiM} = 1$,
$r^{iiA} = r^{iiM} = 0{,}5$.

1.3. Multiple Relations Between Set of Objects

At comparison of objects set among them relations between them are represented in the following way:

$R^{(l)}$: i R j R k R l R h … or $R^{(l)}$: (i R j), (j R k), (k R h) …,

where $R^{(l)}$ means, that the given sequence corresponds to the decision on ranking N objects among themselves, i, j, k, l, h, … objects, which are compared among themselves, and they are elements of one set N, R relations of preference between objects.

Such relation consists of the binary relations set, each of which is established between each pair of objects.

Thus, the given type of the relation is n-sized relation, in this case n shows quantity of objects, between which (or on which) the given relation is established. It is possible still to name the given type of the relation as the multiple relation (MR), emphasizing, that it is established between set of objects. For convenience further we shall use last name of the given type of the relation.

The multiple relation can be presented from set of meanings of the binary relations of which it consists. Therefore multiple relation MR mathematically is convenient for presenting as a matrix.

Let is present N of objects from set A and between each pair of its objects is determined BR. Then it is considered, that on N the multiple relation $R \subseteq N \times N$, concerning their described attributes is given.

Any relation $R \subseteq N \times N$ can mutually uniquely compare Boolean matrixes r, dimension N x N to elements $r_{ij} \in \{0, 1\}$ where i, j = 1..., N numbers of objects.

The relation $R \subseteq N \times N$ between considered objects can be broken into two groups:

If for $\forall BRi \in MR$ is carried out $BRi \in LBR$, MR refers to as the logic multiple relation (LMR);

If $\exists BRi \in MR$ for which is carried out $BRi \in QBR$, MR refers to as the quantitative multiple relation QMR;

Depending on how the meanings of elements are established, QMR can be additive QMR (R^A) or multiplicity QMR (R^M).

Properties of QMR are the following.

For all $\forall i, j, k \in N$ for a matrix r^A is carried out

$$r_{ij}^A + r_{jk}^A = r_{ik}^A + 0{,}5,$$

And for a matrix r^M it takes place

$$(1 / (r_{ij}^M - 1) * (1/r_{jk}^M - 1) = (1/r_{ik}^M - 1).$$

Let there be the sequence of objects $i_1, i_2, i_3, \ldots, i_N$, and between them is determined QBR $R^* \subseteq N \times N$, to which there a matrix r* with elements $r^*_{i_k, i_l} \in [0,1]$ corresponds. We consider that numbers of lines and columns in a matrix r* are located on serial numbers of indexes according to the given sequence of objects.

Definition 6. If for elements of a matrix r* is provided condition

$$r^*_{i_l, i_m} \geq r^*_{i_m, i_l}$$

for all l ≤ m (l – numbers of lines, m – number of columns), QBR $R^* \subseteq N \times N$ appropriate to a matrix r* we shall name as the transitive indistinct binary relation (TQBR).

As a measure of affinity for any two relations $R^{(1)}$ and $R^{(2)} \subseteq N \times N$ we take distances between them on Kemeni:

$$d(R^{(1)}, R^{(2)}) = \sum_{i, j = 1}^{N} \left| r_{ij}^{(1)} - r_{ij}^{(2)} \right| . \quad (1)$$

1.4. Property of a Measure of Affinity

The measures of affinity d satisfy to the following axioms:

The axiom 1. $d(R^{(1)}, R^{(2)} \geq 0$, and equality is achieved only in the event when $R^{(1)}$ and $R^{(2)}$ represent the same ordering.

The axiom 2. $d(R^{(1)}, R^{(2)} = d(R^{(2)}, R^{(1)}$.

The axiom 3. $d(R^{(1)}, R^{(2)}) + d(R^{(2)}, R^{(3)}) \geq d(R^{(1)}, R^{(3)})$ (triangle inequality), and equality is achieved only in the event when the ordering $R^{(2)}$ lays between $R^{(1)}$ and $R^{(3)}$.

The axiom 4. If R′ turns out from R by some rearrangement of objects, and P′ from P by the same rearrangement, d(R′, P′) = d(R, P).

Let's result the following theorem.

The theorem 1. If all elements of the matrix $r^{(1)} = \left\| r_{ij}^{(1)} \right\|$ $r^{(2)} = \left\| r_{ij}^{(2)} \right\|$ of two relations $R^{(1)}$, $R^{(2)}$ differ only on one element $r_{i_1, j_1}^{(1)}$, $r_{i_1, j_1}^{(2)}$, distance between these by two relations $d(R^{(1)}, P^{(1)})$ is defined in distance of these elements, i.e.

$$d(R^{(1)}, R^{(2)}) = \left| r_{i_1, j_1}^{(1)} - r_{i_1, j_1}^{(2)} \right|.$$

The proof. Accordingly to the (1) metrics distance between the relations has additive property. Therefore for distance between relations $R^{(1)}$, $R^{(2)}$ it is possible to present as

$$d(R^{(1)}, R^{(2)}) = \sum_{i, j=1}^{N} \left| r_{ij}^{(1)} - r_{ij}^{(2)} \right| = \sum_{i=1}^{i_1 - 1} \sum_{j=1}^{j_1 - 1} \left| r_{ij}^{(1)} - r_{ij}^{(2)} \right| + \left| r_{i_1, j_1}^{(1)} - r_{i_1, j_1}^{(2)} \right| +$$

$$+ \sum_{i=i_1+1}^{N} \sum_{j=j_1+1}^{N} \left| r_{ij}^{(1)} - r_{ij}^{(2)} \right| = 0 + \left| r_{i_1, j_1}^{(1)} - r_{i_1, j_1}^{(2)} \right| + 0 = \left| r_{i_1, j_1}^{(1)} - r_{i_1, j_1}^{(2)} \right|.$$

Thus, the theorem is proved.

The following consequence follows from the given theorem.

Consequence 1. If the relation $R^{(1)}$, $R^{(2)}$ are identical everywhere, behind exception K – elements, $d(R^{(1)}, R^{(2)})$ it is possible to calculate on distances these K objects.

Thus, each relation (or ordered) is a point of geometrical space.

2. Task Formulation of Decisions Making in Space of a Relative Scale

Basing on initial concepts and definitions given in the previous section we shall formulate the task of the decisions making in a relative scale of measurement.

Given:

1) Objects in quantity N, which it is necessary to rank among them. All these objects belong to the certain class of set of objects: $N \subseteq A$ and consequently are comparable among themselves.
2) It is possible to present set of initial private variants ranking of these objects in quantity M, in the following way:

$$\begin{aligned} &R^{(1)}: i_{11} \geq i_{12} \geq i_{13} \geq i_{14} \geq \ldots \geq i_{1i} \geq \ldots \geq i_{1N}, \\ &R^{(2)}: i_{21} \geq i_{22} \geq i_{23} \geq i_{24} \geq \ldots \geq i_{2i} \geq \ldots \geq i_{2N}, \\ &R^{(i)}: i_{i1} \geq i_{i2} \geq i_{i3} \geq i_{i4} \geq \ldots \geq i_{ii} \geq \ldots \geq i_{iN}, \\ &R^{(m)}: i_{m1} \geq i_{m2} \geq i_{m3} \geq i_{m4} \geq \ldots \geq i_{im} \geq \ldots \geq i_{mN}, \end{aligned} \qquad (2)$$

where $R^{(i)}$ – private (or local) variant of ranking N objects with i number. In structure of a sequence of a rank the expression i_{i1} i_{i2} – corresponds that the object i_{i1} is more preferable or are equal to the object i_{i2}.

The size of preference ≥ is set either qualitatively, or quantitatively.

To each relation $R^{(l)}$ the weight factors $P^{(l)}$, (l=1, m) are compared which characterize its importance.

Required:

On the basis of set of private variants of ranking of objects (2) it is necessary to define such general sequence of ranking:

$$R_k: i_{k1} \geq i_{k2} \geq i_{k3} \geq i_{k4} \geq \ldots \geq i_{ki} \geq \ldots \geq i_{kN}, R_k \subseteq N \times N, \qquad (3)$$

for which is carried out:

1) maximum coordinated with all initial given sequences of ranks: $R^{(1)}$, $R^{(2)}$..., $R^{(m)}$, in view of their "weights" – $P^{(1)}$ (l = 1, m). The given requirement is formulated in this way:

$$F(R_g) = \sum_{i=1}^{m} d(R_k, R^{(i)}) \rightarrow \min, \tag{4}$$

where $d(R_k, R^{(i)})$ – distance between R_k and $R^{(i)}$;

2) Is carried out properties of transitivity. The condition of transitivity for R_k is reduced to the following:

If for three elements $\forall$ (i_{ki}, i_{kj}, i_{kg}) from R_k is carried out conditions ($i_{ki} \geq i_{kj}$) and ($i_{kj} \geq i_{kg}$), for pair ($i_{ki} \geq i_{kg}$) from given three elements will be executed ($i_{ki} \geq i_{kg}$).

3. Conclusions

Both initial private variants of ranking and general variant of ranking of elements of set N, except for a sequence of ranking we shall name as the relations or decisions.

The initial decisions on ranking of objects can be set doubly or separate experts, or previously by system of the decisions making on separate private (or local) criteria (and/or attributes).

In case the initial decisions correspond to the decisions by local criteria, the task (2.1-2.3) is a vector or multi vector task of the decisions making.

If the initial decisions are set by the experts, the task (2.1-2.3) is a task of acceptance of the coordinated decisions. It is possible to name the coordinated decisions still group, emphasizing sense that these decisions are accepted by a commission of experts, but are coordinated.

In the given work the variant of the task of the initial decisions by the experts is investigated; though it does not bring in essential distinctions in the calculations and methods of the decisions-making.

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A NUMERICAL SIMULATION OF HYDRODYNAMICS LOW-CONCENTRATE SOLUTIONS

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A mathematical model of a low-concentrate salt solution movement in a closed curvilinear field is considered. Results of model's numerical calculations in natural variables by the method of fictitious areas are presented. Received graphs demonstrate the salt solution circulation in the selected field.

Keywords: concentration, method of fictitious areas, convergence

1. Theory and Model

The mathematical model of the process of a low-concentrate salt solution movement in a closed volume at presence of evaporation of water from a surface of a reservoir, losses of a deposit salt in those points is presented in [1], where the concentration of the sated solution and inflow solution through the boundary is reached. Such situation arises in reservoirs of a lake type without a drain. The given model was considered in [1] in variable ψ, ω for Π – figurative area, in which the solution flows through a rather small section and there is an encumbrance, which renders influence on shaping of current and formation of areas of loss of a deposit salt.

In the present work the results of the numerical decision of the initial model for curvilinear area Ω, simulating a real outline of some reservoir, in natural variable u, ϑ, P are resulted. We assume that only one source flow in considered area.

Let's consider two-component environment representing a low concentrated solution of some substance in the solvent. $\vec{u}$ and $\vec{\vartheta}$ – mean mass velocities of the solvent and substance, diluted in it; ρ_0, ρ_1 – their density; C – concentration of substance in a solution; density of the solvent in a solution depends on own density of the solvent $\tilde{\rho}_0$ as follows: $\rho_0 = \tilde{\rho}_0(1+KC)$, $K \equiv const$.

For solutions of low concentration influence of impurity on own density of the solvent minor, therefore it is possible to consider:

$$\rho_0 \approx \tilde{\rho}_0 \tag{1}$$

Density of a solution

$$\rho = \rho_0 + \rho_1 \tag{2}$$

In case of an incompressible liquid will depend only on concentration C substances in a solution:

$$\rho = \rho(C), \qquad \rho_1 = \rho C, \qquad \rho_0 = \rho(1-C) \tag{3}$$

Law of conservation of component mass is possible to record as:

$$div(\rho_0 \vec{u}) = \rho_0 \Gamma_0 \tag{4}$$

$$\rho_{1t} + div(\rho_1 \vec{\vartheta}) = \rho_1 \Gamma_1 \tag{5}$$

and for a solution in the whole equation of conservation of mass looks like:

$$\frac{\partial \rho}{\partial t} + div\left(\rho \vec{\vartheta}_p\right) = \rho_0 \Gamma_0 + \rho_1 \Gamma_1 . \qquad (6)$$

Here $\vec{\vartheta}_p$ is the average velocity of a solution, Γ_0 and Γ_1 are velocities of formation of the solvent and substances on a mass unit appropriate component in a solution.

For solutions of low concentration the diffusion of an impurity in a liquid is described by the law of Fick:

$$\vec{\vartheta} = \vec{\vartheta}_p - \frac{\theta}{C} grad\, C , \qquad (7)$$

$$\vec{u} = \vec{\vartheta}_p + \frac{\theta}{1 - C} grad\, C , \qquad (8)$$

where θ – factor of diffusion.

Substituting (7) and (8) in (5) and rejecting the small members of the second order on C , we shall receive

$$\frac{dC}{dt} = div\,(\theta\; grad\; C) + C(\Gamma_1 - \Gamma_0) . \qquad (9)$$

The law of impulse conservation for a solution looks like as follows:

$$\frac{\partial}{\partial t}\left(\rho \vec{\vartheta}_p\right) + \left(\vec{\vartheta}_p \cdot grad\right)\left(\rho \vec{\vartheta}_p\right) + \rho \vec{\vartheta}_p div\, \vec{\vartheta}_p = \rho \vec{F} + div\, \sigma + \rho_0 \Gamma_0 \vec{u}^* + \rho_1 \Gamma_1 \vec{\vartheta}^* , \qquad (10)$$

Where $\vec{F}$ are external mass forces; σ is the stress tensor in a solution;

$$\vec{u}^* = \frac{\Gamma_0 - |\Gamma_0|}{2} |\vec{u}| \qquad \vec{\vartheta}^* = \frac{\Gamma_1 - |\Gamma_1|}{2} \left|\vec{\vartheta}\right| . \qquad (11)$$

At evaporation of the solvent $(\Gamma_0 < 0)$ the steams of the solvent in unit of volume solution for a time unit carry away an impulse equal $|\Gamma_0|\, \vec{u}$. On the contrary, at arise of the solvent $(\Gamma_0 > 0)$ it has entered with zero rate. The similar relation is accepted for substance as well.

Thus, the system of the equations of a low-concentrate solutions movement looks like [1] the following:

$$div\,(\rho_0\, \vec{u}\,) = \rho_0\, \Gamma_0 , \qquad (12)$$

$$\frac{dC}{dt} = div\,(\theta\; grad\; C) + C(\Gamma_1 - \Gamma_0) , \qquad (13)$$

$$\rho \frac{\partial \vec{u}}{\partial t} = \rho\, \vec{F} + div \sigma + \rho_0\, \Gamma_0 (\vec{u}^* - \vec{u}) + \rho\, C\, \Gamma_1 (\vec{\vartheta}^* - \vec{\vartheta}\,) +$$
$$+ \theta \rho_0 (\Gamma_0 + \Gamma_1)\; grad\; \mathrm{C} + \frac{\partial}{\partial \mathrm{t}} (\theta\; grad\; C) + \theta\, (grad\; C \cdot grad)\, \vec{u} + (\vec{u}\; grad)(\theta\; grad\; C) . \qquad (14)$$

On a part of the boundary of area, where the solid walls are assumed, as boundary conditions for a velocity the conditions of an adhesion are accepted, and the concentration condition is not flow out. On a site of the boundary, where a liquid flow in considered area, both components of a velocity are given, and the concentration C received equal by some constant C_0 is smaller then the concentration C_* of the sated solution.

For a research of the given problem it is offered to use a method of fictitious areas with a prolongation on junior factors [2]. A problem is considered in area *D*, strictly containing area Ω $(\Omega \subset\subset D)$, with the boundary S_1. Then, taking into account, that $\sigma = -\mathrm{P}\,\mathrm{I} + \rho\, \nu\, D^*$, where D^* is the tensor of rates deformation (strain) of net water, the equation (14) looks like as follows:

$$\frac{du_\varepsilon}{dt} = \nu\,\Delta u_\varepsilon + \theta^\varepsilon\left(\frac{\partial u_\varepsilon}{\partial y} - \frac{\partial \vartheta_\varepsilon}{\partial x}\right)\frac{\partial C_\varepsilon}{\partial y} - \frac{\partial \mathrm{P}_\varepsilon}{\partial x} + \\ + K^\varepsilon \frac{\partial C_\varepsilon}{\partial x}\left(\Gamma_0 - \frac{1}{C_\varepsilon}\Gamma_1(C_\varepsilon)\right) - \frac{\xi(x,y)}{\varepsilon}\; u_\varepsilon\,, \tag{15}$$

$$\frac{d\vartheta_\varepsilon}{dt} = \nu\,\Delta\vartheta_\varepsilon - \theta^\varepsilon\left(\frac{\partial u_\varepsilon}{\partial y} - \frac{\partial \vartheta_\varepsilon}{\partial x}\right)\frac{\partial C_\varepsilon}{\partial x} - \frac{\partial \mathrm{P}_\varepsilon}{\partial y} + K^\varepsilon \frac{\partial C_\varepsilon}{\partial y}\left(\Gamma_0 - \frac{1}{C_\varepsilon}\Gamma_1(C_\varepsilon)\right) - \frac{\xi(x,y)}{\varepsilon}\;\vartheta_\varepsilon\,. \tag{16}$$

The equation of conservation of mass of net water:

$$u_x + \vartheta_y = \Gamma_0\,. \tag{17}$$

Let's enter for considered current characteristic velocity U, characteristic length l and characteristic concentration C^*. Let's enter into consideration dimensionless values, believing
$x = l\,\bar{x}$, $y = l\,\bar{y}$, $u = U\,\bar{u}$, $p = P\,\bar{p}$, $C = C^*\overline{C}$, $t = l\bar{t}/U$.

After simple computations the (construed) (considered) equations will be transformed to given dimensionless values. Thus the following dimensionless parameters will appear:
$\mathrm{Re} = \dfrac{lU}{\nu}$, $\bar{\theta}^\varepsilon = \dfrac{\theta^\varepsilon C^*_\varepsilon}{lU}$, $\lambda^\varepsilon = \dfrac{\theta^\varepsilon}{lU}$, $\overline{K}^\varepsilon = \dfrac{K^\varepsilon C^*_\varepsilon}{U^2}$.

Then the equation (13) will be recorded as:

$$\frac{dC_\varepsilon}{dt} = div\left(\lambda^\varepsilon\, grad\; C_\varepsilon\right) + C^\varepsilon\left(\Gamma_1 - \Gamma_0\right). \tag{18}$$

The offered model (15)–(18) is used for particular numerical experiment. The rated area represents closed reservoir with the curvilinear boundaries and source. For the numerical decision of the equations system (15)–(18) are used an alternating direction method, obvious scheme of decomposition on the physical factors and method of an over relaxation:

I:

$$\frac{C_\varepsilon^{n+1/2} - C_\varepsilon^n}{\tau} = \frac{1}{2}\left[\frac{\partial}{\partial x}\left(\lambda^\varepsilon \frac{\partial C_\varepsilon^{n+1/2}}{\partial x}\right) + \frac{\partial}{\partial y}\left(\lambda^\varepsilon \frac{\partial C_\varepsilon^n}{\partial y}\right) - u_\varepsilon^n \frac{\partial C_\varepsilon^{n+1/2}}{\partial x} - \vartheta_\varepsilon^n \frac{\partial C_\varepsilon^n}{\partial y} + C_\varepsilon^n\left(\Gamma_1 - \Gamma_0\right)\right]$$

$$\frac{C_\varepsilon^{n+1} - C_\varepsilon^{n+1/2}}{\tau} = \frac{1}{2}\left[\frac{\partial}{\partial x}\left(\lambda^\varepsilon \frac{\partial C_\varepsilon^{n+1/2}}{\partial x}\right) + \frac{\partial}{\partial y}\left(\lambda^\varepsilon \frac{\partial C_\varepsilon^{n+1}}{\partial y}\right) - u_\varepsilon^n \frac{\partial C_\varepsilon^{n+1/2}}{\partial x} - \\ - \vartheta_\varepsilon^n \frac{\partial C_\varepsilon^{n+1}}{\partial y} + C_\varepsilon^{n+1/2}\left(\Gamma_1 - \Gamma_0\right)\right] \tag{19}$$

II:

$$\frac{u_\varepsilon^{n+1/2} - u_\varepsilon^n}{\tau} = -(u_\varepsilon^n\cdot\nabla)\,u_\varepsilon^n + \nu\,\Delta u_\varepsilon^n + \theta^\varepsilon\left(\frac{\partial u_\varepsilon^n}{\partial y} - \frac{\partial \vartheta_\varepsilon^n}{\partial x}\right)\frac{\partial C_\varepsilon^{n+1}}{\partial y} + \\ + K\frac{\partial C_\varepsilon^{n+1}}{\partial x}\left(\Gamma_0 - \frac{1}{C_\varepsilon^{n+1}}\Gamma_1(C_\varepsilon^{n+1})\right) - \frac{\xi(x,y)}{\varepsilon}u_\varepsilon^{n+1/2}\,;$$

$$\frac{\vartheta_\varepsilon^{n+1/2} - \vartheta_\varepsilon^n}{\tau} = -(\vartheta_\varepsilon^n\cdot\nabla)\,\vartheta_\varepsilon^n + \nu\,\Delta\vartheta_\varepsilon^n - \theta^\varepsilon\left(\frac{\partial u_\varepsilon^n}{\partial y} - \frac{\partial \vartheta_\varepsilon^n}{\partial x}\right)\frac{\partial C_\varepsilon^{n+1}}{\partial x} + \\ + K\frac{\partial C_\varepsilon^{n+1}}{\partial y}\left(\Gamma_0 - \frac{1}{C_\varepsilon^{n+1}}\Gamma_1(C_\varepsilon^{n+1})\right) - \frac{\xi(x,y)}{\varepsilon}\vartheta_\varepsilon^{n+1/2} \tag{20}$$

III: $$\frac{\partial^2 P_\varepsilon^{n+1}}{\partial x^2} + \frac{\partial^2 P_\varepsilon^{n+1}}{\partial y^2} = \left(\frac{\partial u_\varepsilon^{n+1/2}}{\partial x} + \frac{\partial \vartheta_\varepsilon^{n+1/2}}{\partial y} \right) \frac{1}{\tau} - \frac{\Gamma_0}{\tau}; \quad (21)$$

IV: $$\frac{u_\varepsilon^{n+1} - u_\varepsilon^{n+1/2}}{\tau} = -\frac{\partial P_\varepsilon^{n+1}}{\partial x}; \qquad \frac{\vartheta_\varepsilon^{n+1} - \vartheta_\varepsilon^{n+1/2}}{\tau} = -\frac{\partial P_\varepsilon^{n+1}}{\partial y} \quad (22)$$

with initial-boundary conditions:

$$C_\varepsilon\big|_{t=0} = C^0(x), \quad \text{in D}, \quad \left.\frac{\partial C_\varepsilon}{\partial n}\right|_{S_1} = 0, \quad (23)$$

for the liquid boundary:

$$C_\varepsilon = C_0(x), \qquad u = 0, \qquad \vartheta = f(x,t), \quad (24)$$

and with concordance conditions:

$$\left[C_\varepsilon\right]\big|_S = 0, \qquad \left.\left[\lambda^\varepsilon \frac{\partial C_\varepsilon}{\partial n}\right]\right|_S = 0, \quad (25)$$

where

$$\xi(x,y) = \begin{cases} 0, & x \in \Omega, \\ 1, & x \in D_1, \end{cases} \qquad \lambda^\varepsilon = \begin{cases} \lambda, & x \in \Omega, \\ \varepsilon\lambda, & x \in D_1, \end{cases} \quad (26)$$

$$\theta^\varepsilon = \begin{cases} \theta, & x \in \Omega, \\ \varepsilon\theta, & x \in D_1, \end{cases} \quad (27)$$

S_1 – boundary of area D, $[u]\big|_S$ – leap (jump) of function on boundary S.

The researched area of current becomes covered uniform on x and y by a grid of cells

$$\Omega = \begin{cases} x_{i+1/2} = (i+1/2)h1, \; i = 0,1,...,N, \\ y_{j+1/2} = (j+1/2)h2, \; j = 0,1,...,M. \end{cases}$$

"Chess grid" here is used. Each cell of a grid is an element of volume of environment, which is characterized calculated in its centre by pressure and concentration. The pressure is calculated with the help of a different equation:

$$p_{i,j}^{n+1} = (1-w)p_{i,j}^n + w\left[\frac{p_{i+1,j}^n + p_{i-1,j}^{n+1}}{h_1^2} + \frac{p_{i,j+1}^n + p_{i,j-1}^{n+1}}{h_2^2} - \frac{1}{\tau}\left(\frac{u_{i,j}^{n+1/2} - u_{i-1,j}^{n+1/2}}{h_1} + \right.\right.$$
$$\left.\left. + \frac{\vartheta_{i,j}^{n+1/2} - \vartheta_{i,j-1}^{n+1/2}}{h_2}\right) + \frac{\Gamma_0}{\tau}\right] / \left(\frac{2}{h_1^2} + \frac{2}{h_2^2}\right).$$

For obtaining of boundary conditions for pressure and velocity the exact condition of an adhesion superseded by approximate condition with the help of decomposition in Tailor set and the equation of movement in a projection to an axis x in boundary points is used.

From a condition of an adhesion $u_{i+1/2,j-1/2} = 0$ follows:

$$u_{i+1/2,j}^{n+1/2} = \frac{u_{i+1/2,j}^n}{2} + \frac{u_{i+1/2,j+1}^n}{6} + O(h_2^3).$$

Taking into account a condition of not flow out $\vartheta_{i,j-1/2}^{n+1} = 0$ for any n, from the equation (22) we have $\vartheta_{i.j-1/2}^{n+1/2} = \frac{\tau}{h_2}\left(p_{i,j} - p_{i,j-1}\right)$.

Then, the difference equation for the calculation of pressure in frontier cells will accept a kind

$$p_{i,j} = \frac{1}{2\left(\tau_0 / h_1^2 + \tau / h_2^2\right)}\left(\tau_0 \frac{p_{i+1,j} + p_{i-1,j}}{h_1^2} + \tau \frac{p_{i,j+1} + p_{i,j}}{h_2^2} - D_{i,j}^{'} + \Gamma_0\right),$$

where $D_{i,j}^{'} = \frac{u_{i+1/2,j}^{n+1/2} - u_{i-1/2,j}^{n+1/2}}{h_1} + \frac{\vartheta_{i,j+1/2}^{n+1/2}}{h_2}$, $\quad \tau_0 = \frac{h_2^2}{8\nu}$.

Modelling. Using the realistic conditions the given model can be applicable for real objects, such as the Balchash lake, Aral sea etc. The numerical experiments were carried out at the following meanings of parameters: $h = 1/21$, $\tau = 0{,}005$, $\varepsilon = 1E-5$, $\Gamma_0 = -0{,}26$, $\mathrm{Re} = 100$, $\omega = 1{,}7$, $\lambda = 1$, $\theta = 0{,}03$.

The rated area covered with a grid 21x21. The balance of evaporation and entering of water was offended against. This was reflected in formation of area of the concentrated solution salt (see Figs. 1, 2)

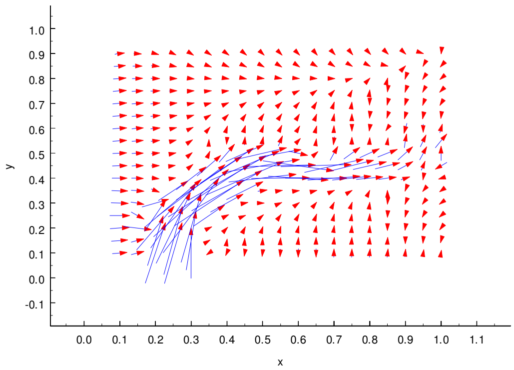

Figure 1. Vector fields

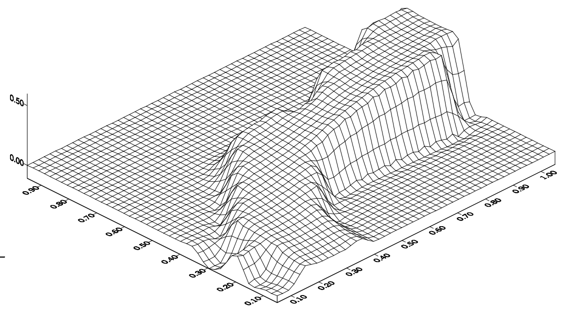

Figure 2. Salt concentration distributions

Conclusions

The obtained graphs of vector's fields (Fig. 1) and the concentration distributions (Fig. 2) characterize circulation of a salt solution in selected area. For condition of balance evaporation and shedding the settling salt in a part of area remote from a source, a salt solution of the greater concentration is accumulated, while in a part of area near to a source, the low-concentrate solution is saved. For diminution ε is observed the good convergence of numerical algorithm. The results of numerical calculations are in a good agreement with the results in [1] and show the efficiency of the presented model using a method of fictitious areas.

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CALCULATION OF COVERAGE NETWORK WIMAX FOR ALMATY – BAYSERKE REGION USING THE MODEL OKUMURA-HATA

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An Internet connection method was suggested for hard to serve areas using the Mobile WiMAX technology. Formulae for calculation of service area were analysed. Speed and the optimal distance for Internet connection was calculated with taking into account a noise. Analyses of experimental data were performed.

Keywords: WiMAX, the base station, the optimal distance, attenuation of WiMAX signal, the method of Okumura-Hata, IEEE802.16e

1. Introduction

WiMAX is one of the technologies to solve the problem of broadband access to transport networks, and in addition, to prevent users from wired connection. WiMAX provides high-speed, secure wireless access to support quality control at the network edge. The aim of the present work is to cover the digital broadcast of the 4th generation of Internet in Bayserke village which has no wired connection. The network of digital terrestrial broadcasting is to provide standard IEEE802.16e - Mobile WiMAX [1] with the formation of the service areas for a given level of a certain frequency.

2. Calculations and Results

To achieve this aim, one must calculate the required power level of the signal at the input of the receiving antenna, which provides the necessary reliability of communications at a certain distance. Table 1 presents necessary data for determination of distance for service area.

Table 1. General parameters for performing of the testing

Parameters					
Frequency of radiation, f *[MHz]*	3500	Losses in antenna feeder BS, B_{FTx} *[dB]*	5,5	Input resistance at receiver, R_{Rx} *[Ohm]*	50
Amplification coefficient of transmitter antenna, G_{Tx} *[dB]*	15	Losses in Duplexer, B_{DRx} *[dB]*	2	Attenuation coefficient in antenna feeder of transmitter, *[dB/m]*	22 dB per 100 m
Amplification coefficient of receiver antenna, G_{Rx} *[dB]*	20	Losses in combiner, B_C *[dB]*	4	Antenna feeder length of transmitter, l_{FTx} *[m]*	25
Power of transmitter BS, P'_{Tx} *[W]*	40	Antenna amplification coefficient of path reception, K_{LNA} *[dB]*	25	Coefficient of log-normal distribution k_{ns}	1,645
Height of antenna BS, h_{BS} *[m]**	300	Height of antenna MS, h_{MS} *[m]*	4	$S\,(k_{ns})$	0,95

* R = 33 km –distance between BS and MS.

In this paper the method of Okumura-Hata is used [2–5]. According to the method Okumura-Hata, signal attenuation of propagation in urban areas is defined by the following formula:

$$L = [69{,}55 + 26{,}16\log(f) - 13{,}82\log(h_{BS}) + [44{,}9 - 6{,}55\log(h_{BS})]\cdot\log(R) - \alpha(h_{MS})]. \quad (1)$$

The correction factor that takes into account the height of the antenna SAR, is calculated for the average size cities in dBusing the formula:

$$\alpha(h_{BS}) = (1{,}1\log f - 0{,}7)h_{BS} - (1{,}56\log f - 0{,}8). \quad (2)$$

Dimensions of base station coverage area will be determined by a range of communication between the base and mobile stations. Communication range will be determined by solving the equation:

$$P_{MS} = P_{RAD} - L(R, h_{BS}, h_{MS}) - B_T - B_E, \quad (3)$$

where P_{MS} – power level signal at the input of a receiving antenna in [dBm]. P_{RAD} – level of the effective isotropic radiated power level in dBm, $L(R, h_{BS}, h_{MS})$ – signal attenuation during propagation in Bayserke village; B_T – additional signal loss at work with a portable subscriber station, which constitute a value of about 3 dB; B_E – additional signal loss when using a portable subscriber station in a building or car (for car is about 8 dB, for the building is 15 dB). The level of effective isotropic radiated power of the transmitter is given by:

$$P_{RAD} = P_{Tx} - B_{FTx} - B_{DTx} - B_C + G_{Tx}, \quad (4)$$

where $P_{Tx}[dBm] = 10\lg P'_{Tx} + 30$ – power level of transmitter in dB/mW.

The basic condition for communication is excess power signal at the input of the receiving antenna with the minimum required power level ($P_{MS\min}$), defined by specifications of receiver according to the formula:

$$P_{MS\min}[dBm] = P_{Rx} - B_{FRx} - B_{DRx} - K_{LNA} + G_{Rx}, \quad (5)$$

where $P_{Rx}[dBm] = 20\cdot\lg P'_{Rx} - 10\cdot\lg R_{Rx} - 90$ – receiver sensitivity in dBm; P'_{Rx} – Receiver sensitivity is in the micro Watt (if the receiver sensitivity is specified in dBm, then P_{Rx} = - 107, dBm).

The additional supply signal power is determined by the statistical parameters of the signal at the mobile communication routes, namely the standard deviations of the signal in the space (σd[dB]) and time (σt[dB]). At the same time numerous experimental studies have shown that the value of σd depends largely on the degree of roughness of the terrain and the range of frequencies, and σt on the communication range. At distances less than 10 km of standard deviation depends on the communication range (r). For practical calculations the data with a high degree of accuracy in the range 300–3500 MHz can be approximated by the formula:

$$\sigma_d = 4{,}1\cdot\log(R) + 5, dB. \quad (6)$$

The standard deviation of the signal in time σt depends on the communication range and reception points located at a distance less than 100 km from the transmitter which is determined by $\sigma_t = 6.5(1 - e^{(-0.036R)}), dB$. The generalized standard deviation signal in the space and time can be calculated by the formula $\sigma = \sqrt{\sigma_d^2 + \sigma_t^2}$. The additional supply of the signal level is calculated by the formula: $P_{MSadd} = k_{ns} \bullet \sigma$ where k_{ns} – coefficient of log-normal distribution, which provides the required reliability.

Thus, in order that signal at the input of the receiving antenna exceeds the minimum signal power at the input of the receiving antenna based on the sensitivity of the receiver, with a given probability, it is necessary to satisfy the condition:

$$P_{MS} \geq P_{MS\,\min} + P_{MSadd}. \quad (7)$$

The value of the desired signal power at the input of the receiving antenna, which provides the necessary reliability of communications, is $P_{MS} = P_{MS\,\min} + P_{MSadd}$,

P_{MSns} = -154+19,95 = -134,05 dBm; -125 ≥ - 134,05; -132 ≥ - 134,05.

The maximum allowable loss in the propagation of a signal on a line is

$$L_{Add} = P_{RAD} - P_{MSns} - B_T - B_E. \quad (8)$$

The maximum communication range is solved by the equation

$$L(R) = L_{Add}. \quad (9)$$

It is possible to solve the equation (9) graphically. All necessary input parameters for the equation (9) are shown in Table 2.

Table 2. Change of the attenuation in dependence with communication range for a car

R [km]	33	35	37	39	41	51	55	57
L (R)	163,5	164,24	164,93	165,6	166,21	168,9	169,9	170,3
L_{Add1},$[dBm]$	172,55	172,4	172,1	171,87	171,72	170,8	170,5	170,3
L_{Add2},$[dBm]$	165,55	165,4	165,1	164,87	164,72	163,8	163,5	163,3
P_{MSns},$[dBm]$	-134,05	-133,9	-133,6	-133,37	-133,22	-132,3	-132	-131,8
P_{MS1},$[dBm]$	-125	-125,74	-126,4	-127,1	-127,7	-130,4	-131,4	-131,8
P_{MS2},$[dBm]$	-132	-132,74	-133,4	-134,1	-134,7	-137,4	-138,4	-138,8

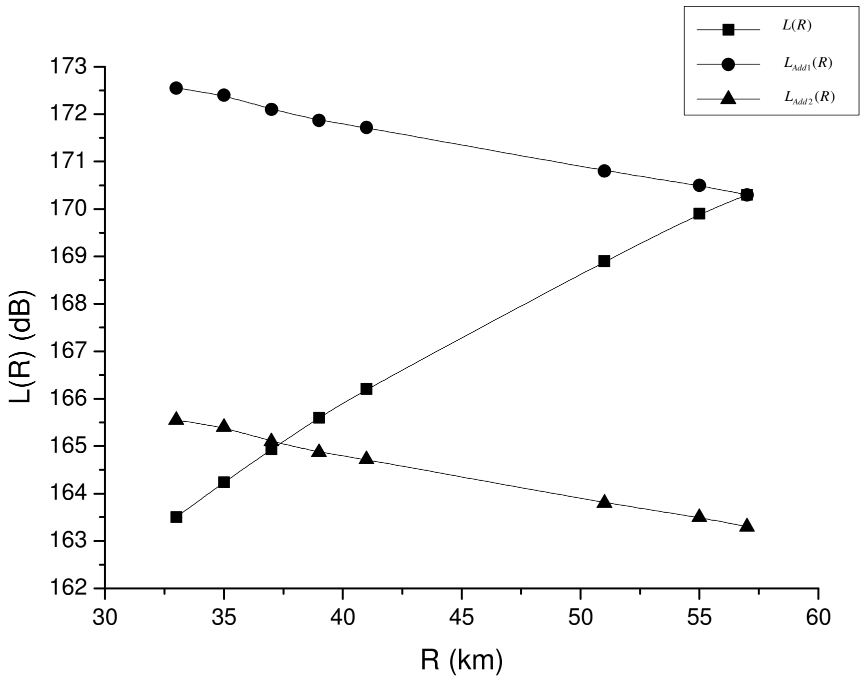

*Figure 1.*Calculation of the maximum range for the car(the intersection of rectangular and triangle lines) and buildings (the intersection of rectangular and circle lines)

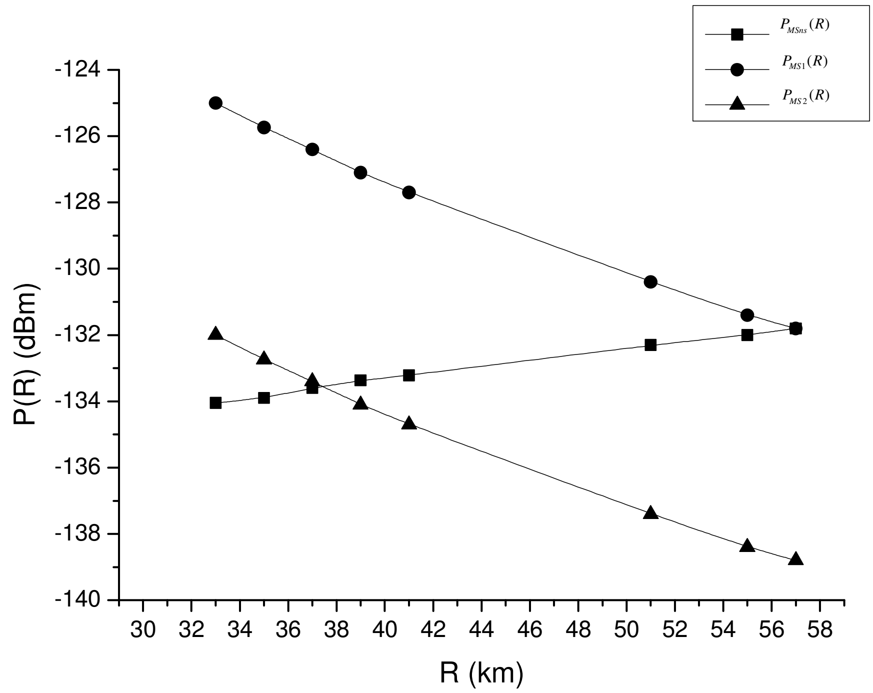

*Figure 2.*The calculation of the required signal power at the input of the receiving antenna, which provides the necessary reliability of communications

On Figure 1 is present the calculated and experimental plots of the attenuation level of signal from a distance. The graph shows that the calculated and measured values of the attenuation of the signal are similar enough to argue that the method of Okumura-Hata is able to calculate the coverage mobile-WiMAX transmitters. The maximum range for the car is R ~ 57 km, suggesting that the ability to connect the entire village Bayserke to the network. The maximum range for the building is R ~ 37 km. It is evident that the presence of certain objects between the host and the base station creates noise and reduces customer service area. On Figure 2 the calculated and experimental plots of the power level signal from a distance are shown.

3. Conclusions

The possibility of applying the technology of broadband wireless mobile-WiMAX was examined. The calculation of the parameters of the network due to moving objects in Almaty Bayserke is based on the standard IEEE 802.16e. The basic technical parameters of the subscriber stations and the radius defined service area were calculated.

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PROCEDURAL STUDY FOR ROUGHNESS, ROUNDNESS AND WAVINESS MEASUREMENT OF EDM DRILLED HOLES USING IMAGE PROCESSING TECHNOLOGY

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In recent years, there have been a number of research studies being carried out on non-contact type metrological measurement since has many advantages over contact type measurements. Whether roundness, waviness and roughness can be evaluated accurately and efficiently or not will directly influence the mechanical products performances and their life. Measuring the roundness and roughness of a workpiece is essential for the engineering industries. For this reason, this paper introduces simple and efficient methodology and algorithms to evaluate the surface roughness, waviness and roundness. Roundness is measured using one of the internationally defined methods of Minimum Zone Circles. The minimum zone criterion is set forth in the current ANSI and ISO standards. Roughness is measured using arithmetic deviation of the roughness and peak to peak height. Waviness was measured using waviness step height. These parameters were measured and studied using video measuring machine and image processing technology through Matlab.

Keywords: roundness, waviness, roughness, Minimum Zone Circles

1. Introduction

The objective of this work is to measure the various geometrical dimensions of a machined hole using Image Processing Technology. The matter is that this method is more accurate than conventional contact type measurement system and more suitable to measure the smaller hole dimensions. Here the holes of 2mm diameter are machined through EDM process. Holes are produced on different set of work-piece using various electrode materials. This is done to find a more suitable electrode for machining a specific work material. The images of the hole are captured with various magnifications, across different cross-sections according to the requirement with video capturing machine. Magnification of images has the advantage of analysing minute details of the hole at different sections. Through image processing techniques the captured images are processed and a set of characteristics related to the image is formulated. The obtained values of required quantities are used to measure the roughness, roundness, taper angle and diameter using different mathematical models. The mathematical model or program will be helpful to simplify the process of profile measurement and it gives accurate results. Figure 1 gives the detailed flow chart for image processing procedure.

2. Literature Review

2.1. Roughness and Waviness

Several researchers have investigated surface roughness measurement techniques using optical methods. Yilbas et al. studied the development of the computer-controlled electro-fibre-optic system for surface roughness measurements and demonstrated that the measurement of the surface roughness could be possible within a limited accuracy [1]. The interferometer technique was utilized to give high accuracy for the surface tilt as well as surface wedge-angle measurement, but it underestimated the accuracy of the surface roughness measurements (Shukla et al.., 1991). Surface roughness detection was carried using the tool-image processing technique. They estimated the valve of the effective roughness of the work piece within acceptable accuracy and report that the model was slightly affected by the feed employed (Galante et al.). A non-contact optical technique for surface roughness measurement was carried out by Kurita et al. (1993). They developed a two-dimensional surface texture, but failed to report the accuracy of the measurement and its validation with the mechanical system. Domonski et al. used an optical system to measure the surface roughness utilizing optical fibres. Two types of surface roughness measurement were presented. These included intensity and polarization – preserving optical fibres (Domonski et al., 1992); in its turn (Silvennoinen et al., 1992) attempted to measure surface roughness using a fibre-optic system, which utilized the specular reflectance of cold-rolled aluminum surfaces.

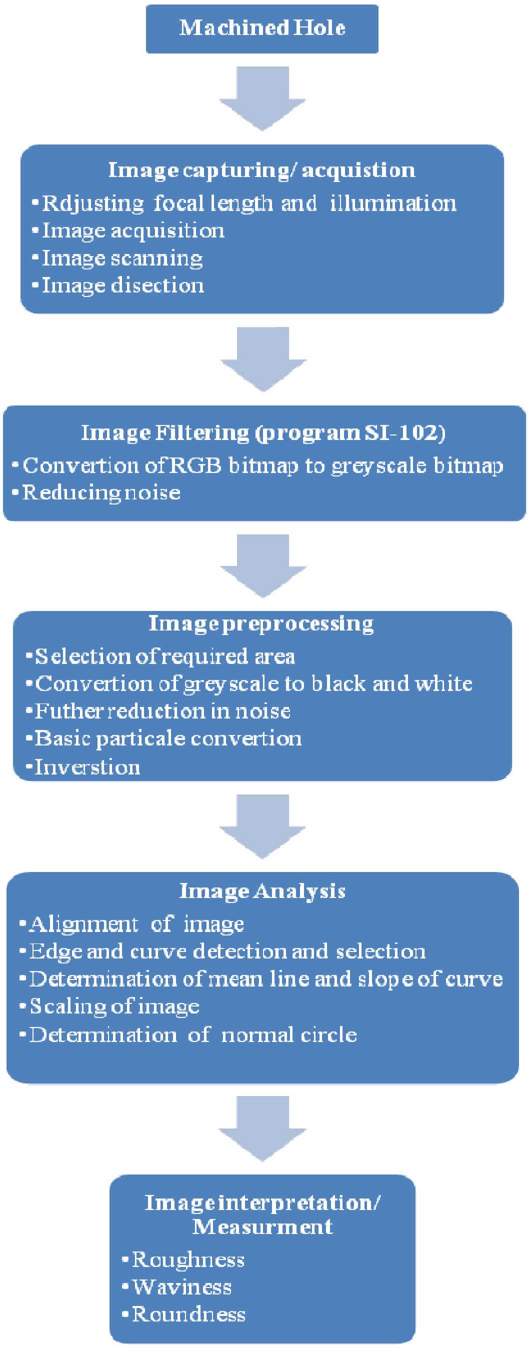


Figure 1. Flow chart for Image processing

A non-contact optical technique for rapidly measuring surface roughness using laser beam was proposed by Kurita et al., 1992. A three-dimensional (3D) surface roughness measurement was carried out by Bengtsson for local wear defects. He concluded that the optical method gave a high accuracy of measurement, but the system response was due to the 3D attempt (Bengtsson, 1991). Roughness measurement using image acquisition has been studied by Popescu et al. This is done with the help of a Linnik roughness microscope, a PC, a video acquisition system and with the use of Lab View graphical programming language [2].

2.2. Roundness

Roundness is defined as a condition of a surface of revolution (like cylinder, cone or sphere) where all points of the surface as a condition of a surface intersected by any plane perpendicular to a common axis in case of cylinder and cone (or passing through a common centre in case of sphere) are equidistant from the axis (or centre). Since the axis and centre do not exist physically, measurements have to be made with reference to surface of the figures of revolution only. Whatever is measured by referring to the surface of revolution is the circular contour. It may be understood that while roundness expresses a particular geometry form of a body of the entire periphery of plane figure. For measuring roundness, it is only the circularity of the contour, which is determined [3].

In the past decade the computational geometric techniques have been used to solving the circularity problems and attracted enormous attention from designers of algorithms. These computational geometry-based algorithms can be applied for evaluation of form errors in the manufactured components [4]. A search procedure to find the minimum radial separation centre for a set of sampled points was proposed by Etesami and Qiao [5]. A faster algorithm for establishing a pair of concentric circles was proposed based on the similar technique by Roy and Zhang. Two theorems based on the *minimax* criterion were developed to solve the roundness evaluation problems using the Voronoi diagrams by J. Huang. The first theorem shows that the exact minimum roundness can be obtained only at an X-type vertex on the max region. The second indicates that the minimum roundness is determined by four critical measured points. Huang further improved this technique to offer an effective way to identify the critical data points at the early stage of computation and gave an efficient approach to solve the circularity problems. Equi-Distant (Voronoi) and newly Equi-Angular diagrams were proposed for establishing the assessment features under different conditions by Samuel and Shunmugam. Four methods are commonly used to evaluate the roundness error: minimum circumscribed circle (MCC), maximum inscribed circle (MIC), minimum zone circle (MZC) and least-square circle (LSC).

3. Problem Statement

The use of mechanical method system has several disadvantages and limitations. These may include:

i. On surface with deep valleys, might not be able to measure with a stylus. This is due to the tip size of the stylus might not be able to penetrate fully to the bottom;
ii. When a spherical stylus passes over a sharp peak, the point of contact moves across the stylus, from one side to another;
iii. Whenever a re-entrant feature is encountered, the stylus tip will lose contact with the profile and will, therefore, obliterate this feature on the graph;
iv. The surface of the work piece may be damaged during the mechanical contact between the stylus and the surface. This is very important in case of mirror-finished surfaces (Yilbas et al., 1997);
v. Since our work piece is made of Ceramic materials, which is very rough, it might damage the probe tip;
vi. Stylus method or contact method gives uneven results, or non-repetitive able results.
vii. The stylus cannot measure surface roughness in a narrow long uneven hole, where the stylus cannot reach.
viii. The roundness of very small or very large holes is hard to measure with contact type measurement.

4. Image Processing Procedure

4.1. Image Capturing

Figure 2 details the image capturing steps. The image was captured by using a video capturing machine, where the image was projected, scanned and stored. Then the image was transferred to metrology software to be filtered and stored. Equipment used:

- Video measuring machine; Make – ARCS, Model KIM1510E
- Software: SI-102
- Intel microcomputer PC Pentium 2.83 GHz, PCI bus, 2 GB RAM Lighting device

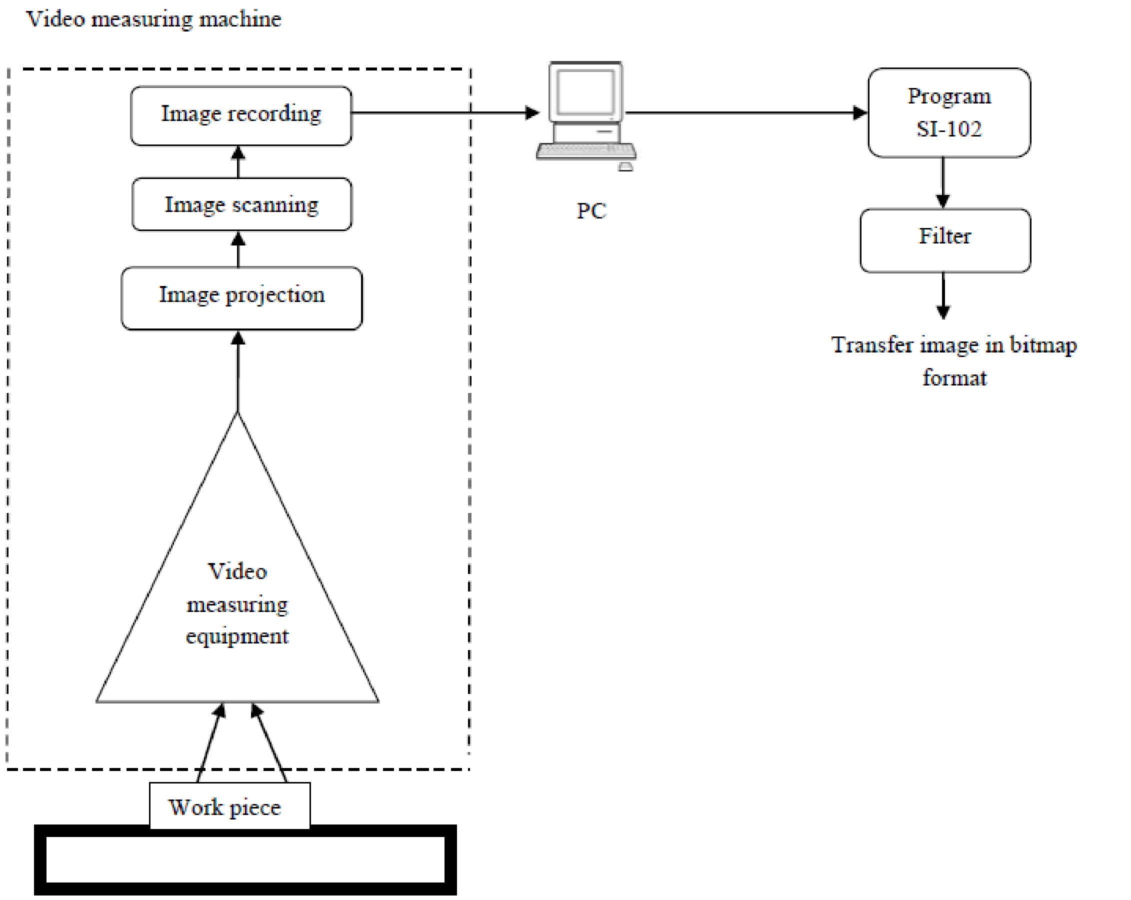


Figure 2. Image capturing process

4.2. Image Preprocessing

Image preprocessing is done in the following steps: Image filtering, manual image preprocessing and software image preprocessing.

4.2.1. Image filtering

In filtering, the image is converted from coloured RGB to grayscale bitmap. Then the unwanted noise is reduced or eliminated. Figure 3 shows the original image of the hole captured by video measuring machine. Figure 4 shows the image after filtering.

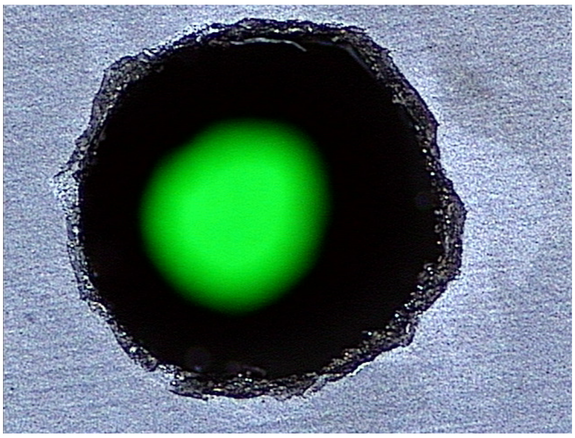


Figure 3. Original image of EDM drilled hole

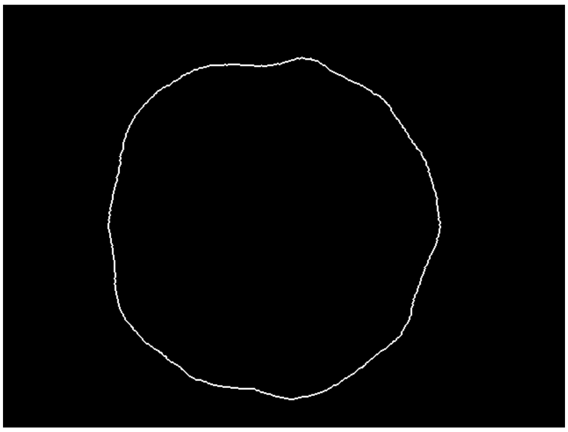


Figure 4. Showing the filtered image

4.2.2. Manual image preprocessing

The needed section is cropped out, and unwanted noise is further filtered out manually. Figure 5 shows the image after initial filtering and Figure 6 the image after selecting section and cropping it. Figure 7 shows the image cropping after manual image pre processing.

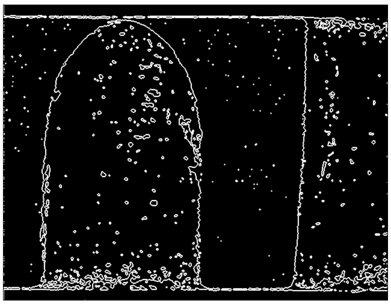


Figure 5. Image after filtering

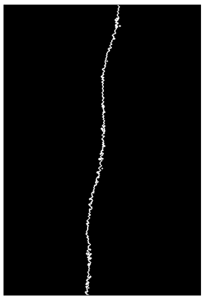


Figure 6. Image after selecting section and cropping it

Figure 7. Display after manual image preprocessing

4.2.3. Software image preprocessing

Image preprocessing is necessary to adjust the acquired picture in a convenient format for analysis and interpretation. This operation must to be done according to user experience, existing functions in libraries and the aim of image acquisition. For this application, image pre-processing consists of two steps, basic particle conversion: convert the acquired image into black and white picture, applying the threshold function segments the image into back-ground and object regions and inversion – convert the threshold image into white and black picture

5. Surface Waviness and Roughness Measurement Procedure

5.1. Measurement Parameters

Surface roughness and topography is very important in telling the characteristic of a surface. Surface texture affects the function of many types of industrial products ranging from roadways and mechanical parts to semiconductors and optics. Moreover, a wide range of methods have been developed for measuring surface texture [6]. Surface roughness measurement presents an important task in many engineering applications [7]. Surface must lay within a certain range of roughness for good quality products or part. Every surface has some form of texture that takes the form of peaks and valleys. These peaks and valleys vary in height and spacing and have properties inherent in the way the surface having been produced or utilized [8].

The main way of measuring surface roughness is by contact based instruments especially using stylus instruments. Measurement is obtained by using a stylus drawn along the surface to be measured; the stylus motion perpendicular to surface is registered. This registered profile is then used to calculate the roughness parameter.

The most important sources of error in stylus measurement are as follows: stylus size, stylus load, speed of traverse and filtering caused by skidding [8]. There is also the problem stylus cannot measure extremely smooth surfaces or extremely rough surfaces since the stylus might get damaged. Therefore, non-contact type measurements techniques are used, especially optical measurement, like light scattering, speckle techniques, reflected beam intensity profile, video measuring machine.

Owing to the sudden development of the data acquisition systems and especially of the video ones, as well as to the technical and miniature performances, which the image caption systems attained (video camera) the designing and execution of some systems based on the acquisition image working principles has become possible. The high image resolution, a very good contrast of the most up-to-date modern equipment enable the images acquisition representing complex contours difficult to measure with classical instruments. Thus, by images acquisition the contour may be visualised, magnified by a convenient factor, the distances and areas difficult to measure or calculate by common methods could be also processed. The great advantage of this equipment is the elimination of the measurements based on mechanical contact and hence the elimination of all the errors inherent to it. Also, the speed with which the measurement and data processing can be made is superior to other methods. Finally, we can remark the high flexibility degree concerning the measuring range. In this respect it can be concluded that these measuring techniques have an open field of development (Popescu et al., 1999).

In this paper, the surface roughness was found using video measuring machine (ARCS, Model KIM1510e) and image processing using Matlab. For roughness the hole is cut in half along the axis. Then the image is taken using video measuring machines.

The roughness of the surface is defined as the ensemble of the irregularities that form the relief of the real surface, the pace of which is relatively small as compared to their depth [9]. The surface texture of sides of the cross-sectional view was found. Two parameters were used to find surface texture. One is Waviness, the other Roughness.

Waviness was found using waviness height. Waviness height (W_t) is defined as the vertical distance between the highest and the lowest point for a waviness filtered profile. Figure 8 shows the waviness for the selected sample length.

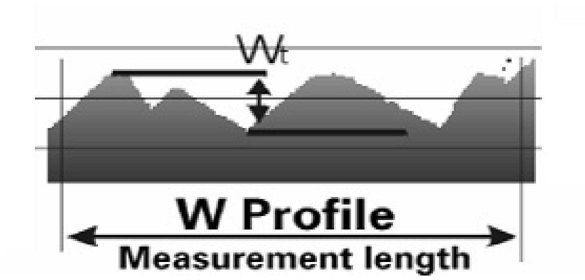


Figure 8. Waviness height

$$W_t = W_{\max} - W_{\min}\,, \tag{1}$$

where W_{max}, W_{min} represent the maximum peak and minimum valley. For surface roughness two quantitative parameter were used: arithmetic average deviation of roughness and Peak to peak height.

Arithmetical mean deviation from the mean line of profile (R_a) is defined as the average valve of the coordinates (y_1, y_2, …. , y_n) from the mean line. The coordinates are summed up without considering their algebraic sign.

The arithmetic average deviation of the roughness, R_a:

$$R_a = \frac{1}{l}\int_0^l |y(x)| dx\,, \tag{2}$$

or, approximately,

$$R_a = \frac{\sum_0^n |y_i|}{n}\,, \tag{3}$$

where *n* is the number of divisions over the sample over the sampling length *l*.

Peak to peak height is defined as the height difference between the highest and lowest pixel in the image. Peak to peak height was measured using Ten Point Height, where the difference of the five high local maximums and five low local minimum in a continuous sample length. Ten Point heights were got by selecting a sample length of relative a linear path [3].

$$R_z = \frac{1}{5}\sum_{i=0}^{5}(y_{pi} - y_{vi})\,, \tag{4}$$

where y_{pi} are the most important five upper points (y_1, y_3, y_5, y_7, y_9) and y_{vi} are the most important five lower points of the profile (y_2, y_4, y_6 ,y_8 , y_{10}) and shown on Figure 9.

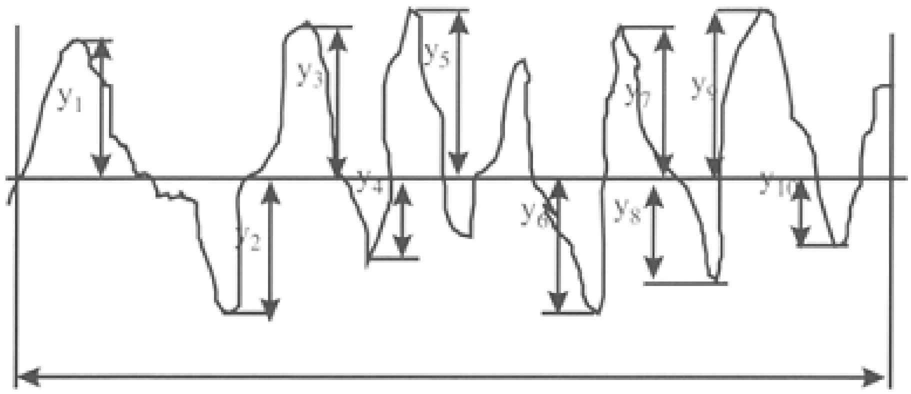


Figure 9. Ten point roughness measurement

Equation (5) is used to convert R_a to R_z [2]:

$$R_z=4.5(R_a)^{0.97}. \quad (5)$$

Peak to valley height was also used to represent the roughness value. This is defined as the separation of highest peak and lowest valley. There are also other roughness parameters, but in this paper only the enumerated parameters will be analysed.

5.2. Image Analysis

Through image analysis the subject picture is processed into a format that contains useful information according to desired application. To determine the roughness parameters, the following steps should be performed:

i. *Image uploading:* to upload the image to the program and covert the grey scale image (1 to 255 pixel threshold colour scale) to black and white image (0s and 1s only). This is to make it possible to distinguish between the background and the curve.

ii. *Edge detection and curve detection:* the image obtained through the described installation represents a light slit corresponding to irregularities on test surface [2]. The edge of the curve was detected by using an incremental loop to find the x, y coordinates of the curves. The curve boundaries were represented by zeros after converting image to black and white of zeros and ones. The coordinates of the curve was stored in a matrix in the program. The coordinates were got by analysing the bitmap image and scanning the pixel array for zeros.

iii. *Determination of reference line:* the reference line is the equidistant to centre line. The centre line of profile divides the real profile so that the sum of the squares of the profile ordinates to this line to be minimum [2]. The mean line was found by using a function called "linefit" in Matlab. This fits the line using least square method: $\overline{Y} = a + b\overline{X}$, $b = \frac{\sum_{i=1}^{n} X_i Y_i - n\overline{XY}}{\sum_{i=1}^{n} X_i^2 - n\overline{X^2}}$. The equation of mean line is: $y = bx + a$, where $\overline{Y}$ is the mean of Y valves $\overline{X}$ is the mean of X valves, n is the number of coordinates. Using the equation of the line the mean line is plotted.

iv. *Image alignment:* After the determination of reference line, the slope was calculated and the image was rotated so that the reference line to be parallel to X axis [2].

5.3. Image Interpretation

Using the processed image, the interpretation was carried out to extract the required information. To determine the waviness, the following steps to be followed:

i. Calculating the distance of the each pixel point with reference to the mean line. This is done by studying the bitmap image, and scanning the pixels array from the profile and determining the difference in the y-axis with the mean line.

ii. Determination of the max peak and lowest valley points in the curve.

iii. Calculation of waviness step height using the related equation and algorithm.

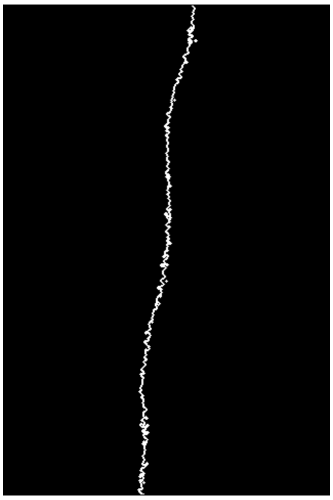


Figure 10. Filtered and preprocessed image

To determine the roughness, the following steps to be followed:

i. The image containing the rotated curve is displayed (Fig.10) with max peak line, mean line and minimum valley.

ii. Three samples lengths are chosen manually using the software. The samples are chosen by selecting the starting point and end point in the displayed curve (Fig. 11 & 12).

iii. For each sample length the pixels array is scanned between the selected pixels or boundaries. The arithmetic deviation of the roughness is calculated using equation and algorithms. As well as, the peak to valley height is calculated.

iv. The average peak to peak height and average peak to valley height is calculated.

v. The average peak to peak height roughness is calculated using equation and algorithms and average deviation of the roughness (Fig. 13).

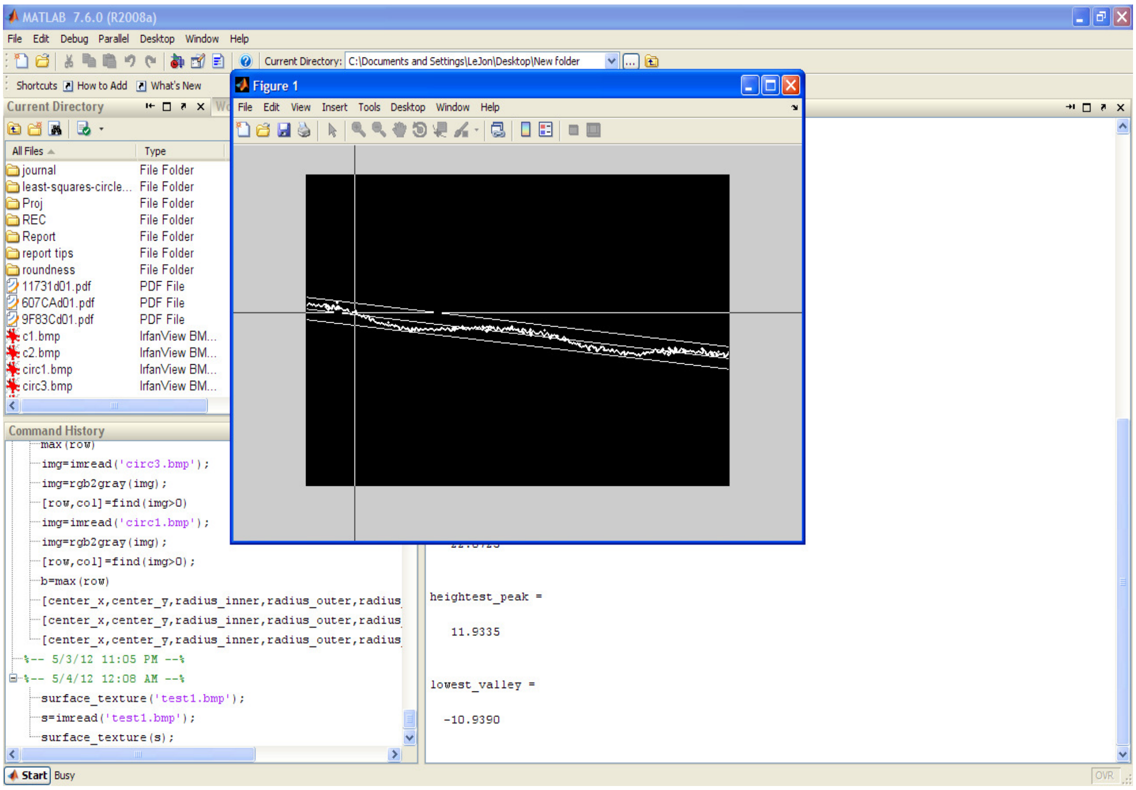


Figure 11. Displayed image with max line, mean line and min line, for selecting starting point of sample

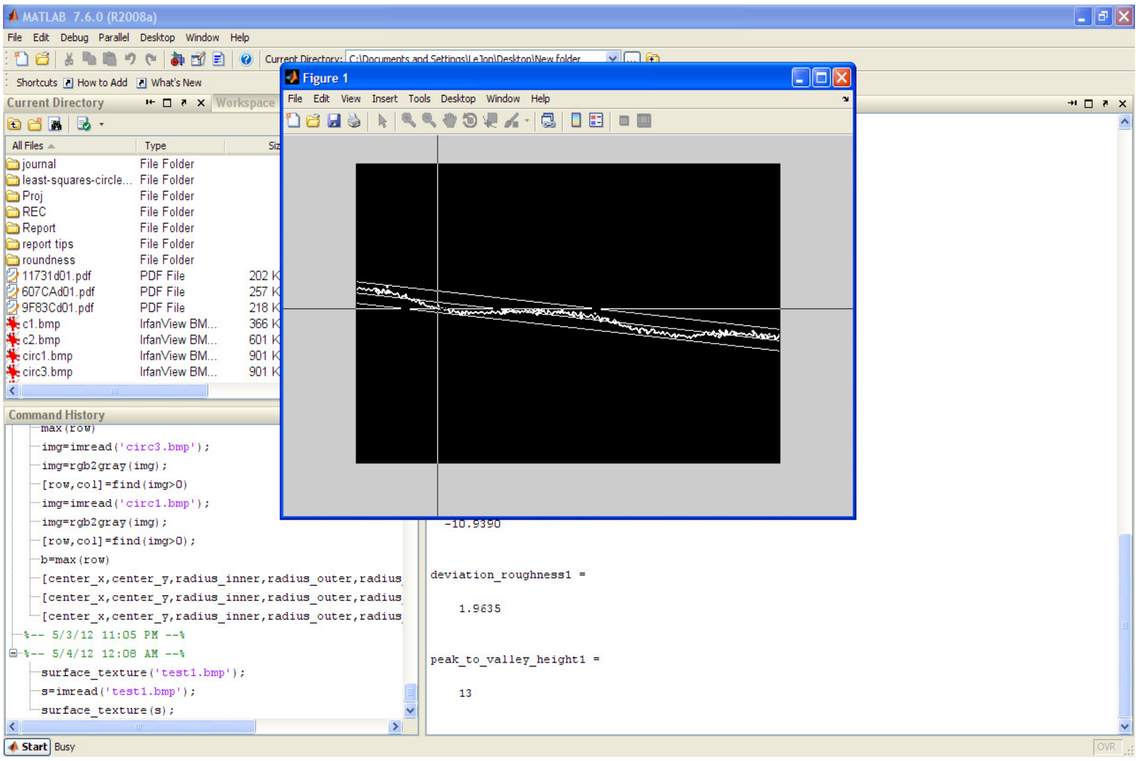


Figure 12. Selection of end point of sample on Figure 11

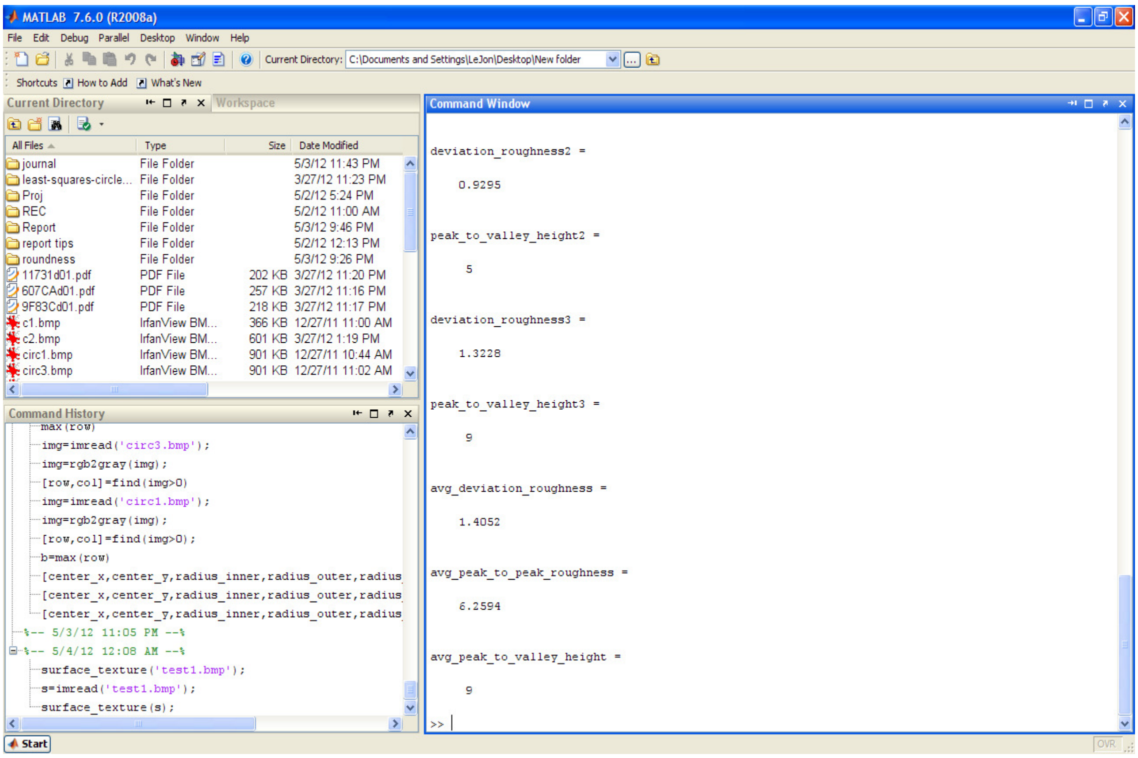


Figure 13. Display of results

Table 1. Results obtained for image processed above

Measurement Parameter	Values in pixels
Waviness	22.8725
Maximum peak height	11.9335
Maximum valley depth	-10.9390
arithmetic deviation of roughness for sample length 1	1.9635
peak to valley height for sample length 1	13
arithmetic deviation of the roughness for sample length 2	0.9295
peak to valley height for sample length 3	5
arithmetic deviation of the roughness for sample length 3	1.3228
peak to valley height for sample length 3	9
Average arithmetic deviation of the roughness	1.4052
Average peak to valley height for sample length	9
Average peak to peak roughness	6.2594

6. Roundness Measurement Procedure

Circular feature is one of the most basic geometric elements of mechanical parts [X. M. Li., Z. Y. Shi]. In manufacturing environments, variations on circular features may occur due to imperfect rotation, erratic cutting action, inadequate lubrication, tool wear, defective machine parts, chatter, misalignment of chuck jaws, etc. [10].

Mostly roundness measuring instruments are contact-type. Diametric roundness measurements can be conducted using two point measuring instruments such as micrometers, callipers or indicating snap gages. The primary error of two-point measuring process is that the measured points are limited in practice, and the midpoints are not located at the same position in a plane.

Recently, the coordinate measuring machines CMMs) have been used to measure roundness errors. Coordinate measuring process of CMMs is very time-consuming provided that a large set of measured points is collected [11]. The traditional instruments for roundness measurement generally apply the least squares technique to evaluate roundness errors from measured points. The least squares technique may cause large deviations [12].

Whether roundness error can be evaluated accurately and efficiently or not will directly influence the mechanical products performance and life. Therefore, there is a requirement to develop an automatic inspection method that will satisfy the needs of roundness inspection. Fairly extensive research in the area of roundness evaluation and inspection is still underway.

The ANSI dimensioning and tolerance standard Y14.5 defines form tolerances of a component with reference to an ideal geometric feature [13–15]. Various researchers have attempted to develop methods for establishing the reference feature and to evaluate the circularity error. Several geometry measurement techniques are available to estimate the reference feature (circle) [16]. Four methods are commonly used to evaluate the roundness error, namely minimum zone circle (MZC), maximum inscribed circle (MIC), minimum circumscribed circle (MCC) and least-square circle (LSC). Among these four methods, only the MZC complies with ANSI and ISO standards and has the minimum roundness error value. This paper introduces simple and efficient algorithms to evaluate the roundness by MZC method using image processing technology.

Owing to the development of the data acquisition systems it is possible to get high resolution images of contours that are difficult to measure with classical instruments. Thus, by images acquisition the contour may be visualized, magnified by a convenient factor and by using image processing technology the distances and areas, which are difficult to measure by common methods can also be processed. The great advantage of this method is the elimination of the measurements based on mechanical contact and hence the elimination of all the errors inherent to it. Finally, we can remark the high flexibility concerning the measuring range. In this respect it can be concluded that these measuring techniques have an open field of development [17].

6.1. Measurement Parameters

Roundness is defined as a condition of a surface of revolution (like cylinder, cone or sphere) where all points of the surface as a condition of a surface intersected by any plane perpendicular to a common axis in case of cylinder and cone (or passing through a common centre in case of sphere) are equidistant from the axis (or centre). Since the axis and centre do not exist physically, measurements have to be made with reference to surface of the figures of revolution only. Four methods are commonly used to evaluate the roundness error: minimum circumscribed circle (MCC), maximum inscribed circle (MIC), minimum zone circle (MZC) and least-square circle (LSC).out of these four methodology minimum zone circle is considered as most accurate one[11]In this method, two circles are used as reference for measuring the roundness error. One circle is drawn outside the roundness profile just as to enclose the whole of it and the other circle is drawn inside the roundness profile so that it just inscribes the profile. The roundness error here is the difference between the radiuses of the two circles.

The image of the holes for which the roundness has to be found is captured using video measuring machine (ARCS, Model KIM1510e). The images captured undergo a filtering process in order to reduce the noises present. The filtered image is then processed using the MATLAB software to obtain the roundness value.

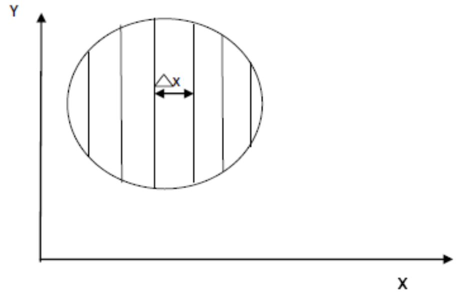


Figure 14. Pixel scanning for X coordinates

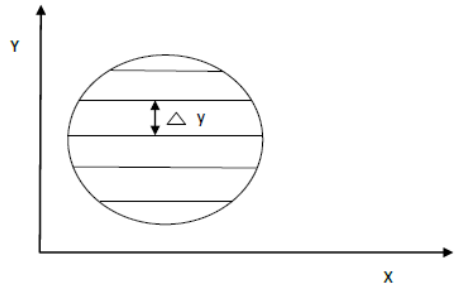


Figure15. Pixel scanning for Y coordinates

Every Dx and Dy represents one pixel gap in x and y direction. For each pixel gap the image is scanned and the corresponding x-y coordinate is found out and stored in a matrix form represented by row and column respectively. This is shown on Figures 15 &16.

From these coordinates value, the rough coordinates of the centre can be found out.
Coordinate X_c=mean (row), Coordinate Y_c=mean (column). X_c and Y_c are the coordinates of the centre.

The centre coordinates are then used to find the distance between the centre and every point on the circle. The distance d_i is calculated using the equation:

$$d_i = ((X_c - x_i)^2 + (Y_c - y_i)^2)^{1/2}, \quad 6)$$

where x_i and y_i represents the x and y coordinate value of each point on the circle respectively. d_i represents the distance of each point from the centre of the circle.

Now, the average of this distance is obtained and is considered to be the radius of the reference circle (R_{ref}). The reference circle is now drawn using the standard equation of a circle:

$$(X - X_c)^2 + (Y - Y_c)^2 = r^2 . \quad (7)$$

Now, the minimum outer circle and the maximum inner circle to the measured points set can be found from distance obtained using Equation 1.

The maximum inner circle is drawn such that it is present within the original circle and just touches the innermost point of the original circle.

The maximum outer circle is drawn such that it encloses the original circle completely and just touches the outermost point of the original circle.

The radius of the minimum outer circle to the measured points set, $R_{max}=Max\{R_i\}$ is the maximum distance between points which lie on the circle and the centre of the circle. The diameter of the minimum outer circle is $D=2R_{max}$. The radius of the maximum inner circle to the measured points set, $R_{min}=Min\{R_i\}$ is the minimum distance between points which lie on the circle and the centre of the circle.

The diameter of the minimum inner circle is $D=2R_{min}$.

The objective is, $R_{max} - R_{min}$, i.e. to find the minimum radial separation between the minimum outer and the maximum inner circle.

Subject to the following constraints:

$$((X_c - x_i)^2 + (Y_c - y_i)^2)^{1/2} \le R_{\max} . \quad (8a)$$

The radius of the maximum inner circle should be less than or equal to the distance of all the points on the circle from the centre. This is to ensure that all the data points that lie on the original circle lie on or just outside maximum inner circle:

$$((X_c - x_i)^2 + (Y_c - y_i)^2)^{1/2} \geq R_{\min} . \qquad (8b)$$

The radius of the minimum outer circle should be greater than or equal to the distance of all the points on the circle from the centre. This is to ensure that all the data points that lie on the original circle lie on or just inside maximum inner circle, where $i = 1, 2, 3, ..., N$, and N represents the number of data points on the circle.

Constraints (8a) and (8b) are needed to make sure that the original circle lie within the minimum outer and the maximum inner circle. This means $R_{\max} - R_{\min} \geq 0$, $x_l \leq X_c \leq x_u$, $y_l \leq Y_c \leq y_u$, where x_l , y_l are the lower bounds of X_c and Y_c , x_u , y_u are the upper bounds of X_c and Y_c . The roundness is represented by $Z_e = \{R_{max} - R_{min}\}$.

6.2. Image Analysis

Through image analysis the subject picture is processed into a format that contains useful information according to desired application. To determine the roundness the following steps should be performed.

i. *Image conversion:* Convert a grayscale image (1 to 255 pixel threshold colour scale) to black and white image (0s and 1s only) and the upload the image to the program. This is done to make it possible to distinguish between the background and the circle.
ii. *Detection of the circle:* The image obtained through the described installation represents a light slit corresponding to the boundary of the hole which is a irregular circle. The circle was detected by using an incremental loop to find the x, y coordinates. The boundary of the circle was represented by zeros after converting image to black and white of zeros and ones. The coordinates of the points on the circle was stored in a matrix format in the program. The coordinates were got by analysing the bitmap image and scanning the pixel array for zeros.

6.3. Image Interpretation

Using the processed image, the interpretation was carried out to extract the required information. To determine the roundness, the following steps to be followed:

i. From the coordinates value obtained through image analysis, the rough coordinates of the centre was found out (Fig. 17).
ii. The centre coordinates were used to find the distance between the centre and every point on the circle. This is done by studying the bitmap image, and scanning the pixels array from the profile.
iii. With this distance the reference circle was found out using the standard equation for a circle.
iv. The radius of minimum outer circle and the radius of maximum inner circle were found using the algorithms and the proposed methodology.
v. The roundness is the difference between the radius of the minimum outer circle and the radius of maximum inner circle (Figs. 18 & 19). Results of Figure 20 is shown in Table. 2.

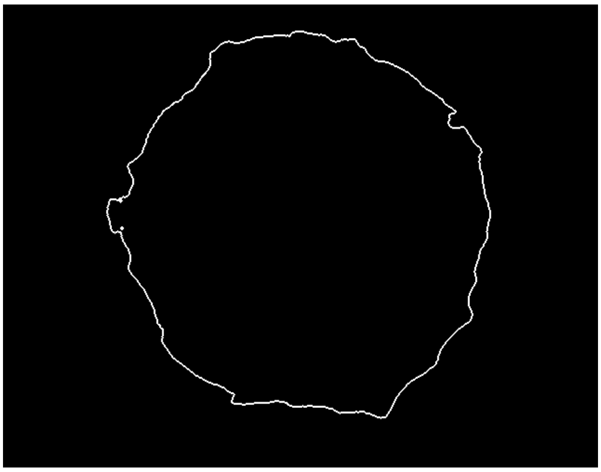


Figure 16. Filtered and preprocessed image

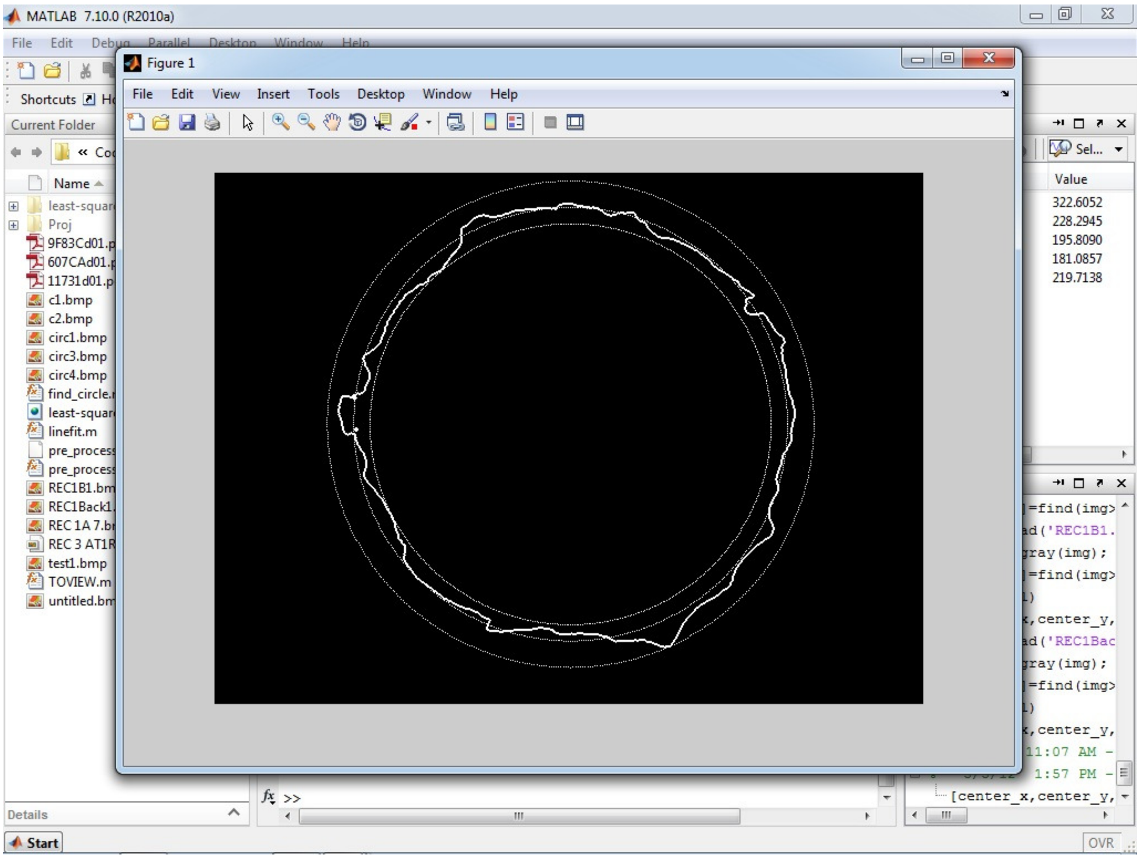


Figure 17. Display of image after processing

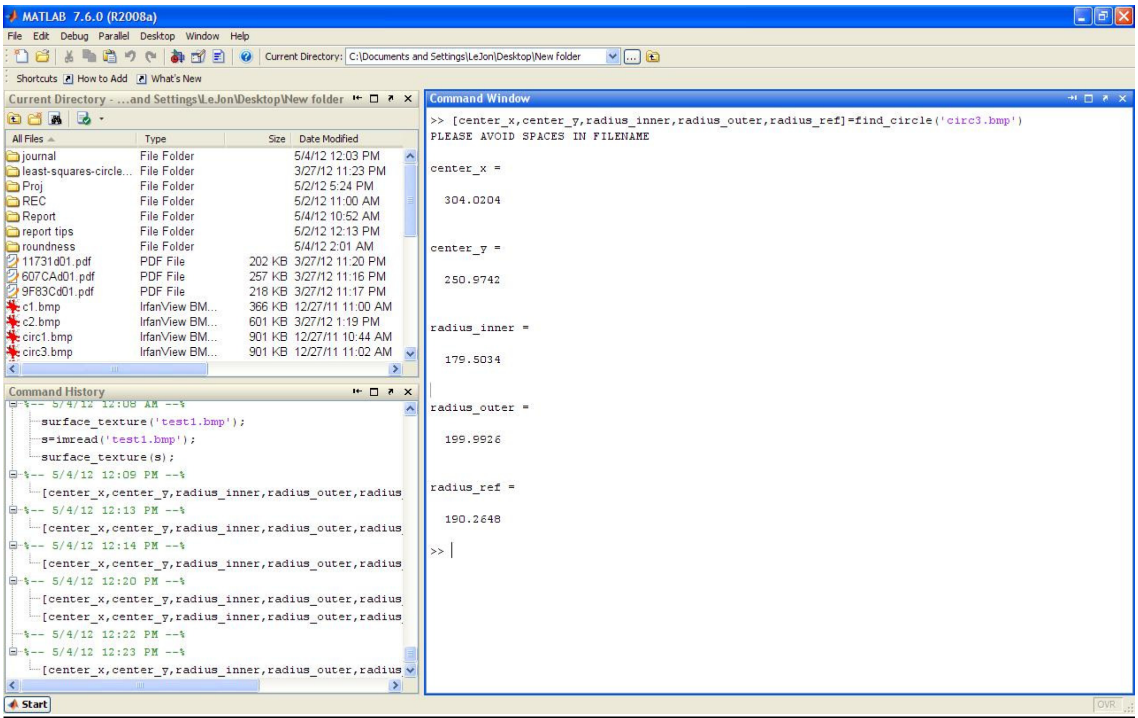
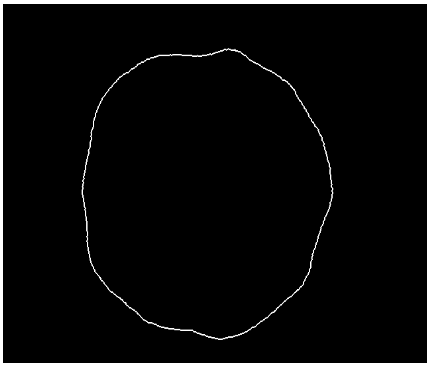
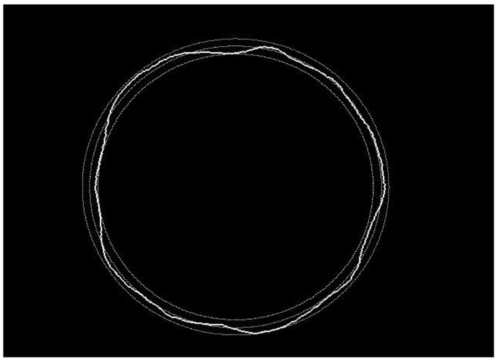


Figure 18. Display of results





(a) (b)

Figure 19. a) The image of sample 1 before processing; b) The Image of sample 1 before processing

Table 2. Roundness measurement parameters

Measurement Parameters	Values in pixels
Centre x	304.0204
Centre y	250.4747
Reference circle radius	190.2647
Maximum inner circle radius	179.5034
Minimum outer circle radius	199.9926

7. Conclusions

Surface texture affects the function of many types of industrial products ranging from mechanical parts to semiconductors and optic. Roundness is one of the basic form errors encountered in circular features. This paper introduces simple and efficient mathematical model and algorithms to evaluate the surface roughness, waviness and roundness using image processing technology. The surface texture was found using the standard 10-point peak and valley method, deviation of roughness and step waviness height. The roundness was obtained using MZC methodology, which complies with ISO standards. The images of the EDM machined holes were captured by a video capturing system. These images were then processed with a set of algorithm developed using the proposed mathematical model. A set of characteristics related to the image were obtained. This data was used to obtain the surface roughness, waviness and roundness of the drilled hole. The developed image processing technology can be an effective tool for measurement of surface texture and roundness.

The research had a main objective to demonstrate that the measurement of small dimensions using image processing technology is possible. The advantages of this application consist in the substitution of human operator for measuring the parameters manually. It is also important to mention that, beginning with the first step – the image acquisition – to the last step – the displayed result, all the information has a computer format, so that it could be stored, transmitted at long distance (e.g. by the help of Internet), printed, etc. Advantages of image processing using video measuring machine:

i. The image can be processed in remote locations, stored and transferred easily.
ii. Produces repetitive results.
iii. More precise than stylus method.
iv. No wear or contact damage.
v. Ones calibration and set-up is done, roughness measures take shorter time.
vi. Accurately depends on quality of image or video measuring machine.
vii. Our method does not require highly polished surface like beam or light scatter techniques.
viii. Can measure roughness of highly polished surface.
ix. Cost less than most optical methods.

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Transport and Telecommunication Institute, Lomonosov 1, LV-1019, Riga, Latvia

REVIEW OF IMPLEMENTATION OF TUTORING DIALOGUE WITH STUDENT IN THE INTELLIGENT TUTORING SYSTEM *AUTOTUTOR*

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An overview of the implementation of five-step dialogue frame in intelligent tutoring system AutoTutor, simulating a dialogue between the tutor and learner, is presented. These intelligent tutoring systems provide a substantial assistance to the teacher in making learning material to be easily mastered by learners.

Keywords: intelligent tutoring system, language analyzer, latent semantic analysis, dialogue move generator, semantics

1. Introduction

The process of formation of a conceptual and semantic basis of a learning material for students normally is implemented in the form of the individualized question-explanatory multi-step dialogues. The efficiency of the tutoring dialogue depends on the experience and talent of the tutor. Intelligent tutoring systems (ITS) provide a substantial assistance to the tutor in the preservation of this unique experience, as well as in formation of the understanding of learning material by learners [6, 7].

The system *AutoTutor* developed at University Memphis is designed for conducting a dialogue in English language. Further the article reviews the graphic interface of the student and structure of implementation of five-step model dialogue.

2. Graphic Interfaces of the Student and Structure of Implementation of Five-Step Dialogue Frame

AutoTutor graphic interface of the student contains four areas (see Figure 1): three-dimensional agent for language synthesis; question output area for the analysis of a specific topic; area for input of student responses and achievement of a feedback in the form of comments received from the system; dialogue history area for viewing the previous dialogues.

For conducting a dialogue the AutoTutor uses five-step dialogue frame: 1 TUTOR asks a difficult question or presents a problem; 2 STUDENT gives an initial answer; 3. TUTOR gives short feedback on the quality of the answer; 4. TUTOR and STUDENT have a multi-turn dialogue to improve the answer; 5. TUTOR assesses whether the student understands the correct answer [2].

Such process of constructing explanations, specifications and mental models of a material is extremely necessary for tutoring and is normally more effective than simple providing of information to the learner [5]. The five-step model dialogue in AutoTutor ITS is implemented by the modules that are outlined in the following section.

3. Structure of Implementation of Five-step Model Dialogue

The five-step model dialogue is implemented by the following modules: animated agent; curriculum script; language analyser; latent semantic analyser (LSA); dialogue move generator.

Animated agent is a three-dimensional graphic simulator of the tutor. AutoTutor communicates with the learner via the synthesized speech, facial expressions, and elementary pointing gestures.

Curriculum script. Each script contains the content associated with a question or problem. For each, there is (1) the ideal answer; (2) a set of expectations; (3) families of potential hints, correct hint responses, prompts, correct prompt responses, and assertions associated with each expectation; (4) a set of misconceptions and corrections for each misconception; (5) a set of key words and functional synonyms; (6) a summary; and (7) mark-up language for the speech generator and gesture generator for components in (1) through (6) that require actions by the animated agents. Subject-matter experts can easily create the content of the curriculum script with an authoring tool called the AutoTutor Script Authoring Tool [5].

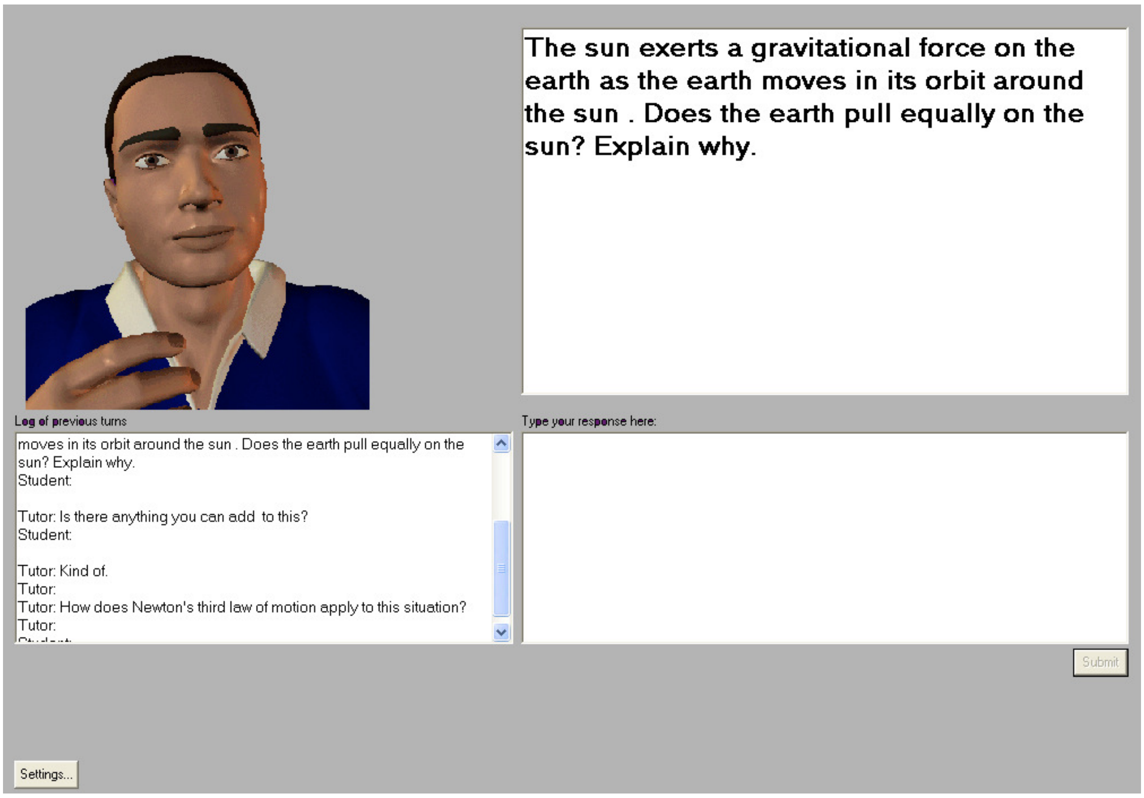

Figure 1. ***AutoTutor*** graphic interfaces [1]

Language analysers. AutoTutor contains several language analysers that operate on the words that the learner types into the keyboard during a particular conversational turn. These analysers include: (1) a word and punctuation segmenter, (2) a syntactic class identifier, and (3) a speech act classifier. After the learner constructs a message and clicks the Enter key, the message is broken down into individual words and punctuation marks. The syntactic class identifier then matches each word to the appropriate entry in a large lexicon (approximately 10,000 words) and identifies all possible syntactic classes and user frequencies in the English language [4]. For example, "program" is a noun, verb, or adjective. A neural network then assigns the correct syntactic class to word (W), taking into consideration the syntactic classes of the preceding word (W-1) and the subsequent word (W+1). AutoTutor is capable of segmenting the learner input into a sequence of words and punctuation marks with 99%+ accuracy, of assigning alternative syntactic classes to words with 97% accuracy, and of assigning the correct syntactic class to a word (based on context) with 93% accuracy [3].

The speech act classifier is a neural network that segments and classifies the learner's input into one of five speech act categories. The five categories are: Assertion, WH-question, YES/NO question, Directive, and Short Response. The Assertions are most relevant to our present implementation of LSA. Namely, LSA is used to assess the quality of a learner contribution once it has been classified as an Assertion. The LSA quality assessments play a critical role in determining the type of feedback and dialogue move AutoTutor will generate next. AutoTutor uses different strategies for dealing with the other speech act categories: WH-question, YES/NO question, Directive, and Short Response. These strategies, which are needed for a smooth mixed-initiative dialogue, will not be addressed in the present article [4].

Latent semantic analysis (LSA). Thus, LSA computes a conceptual relatedness value between any two bags of words in which each bag contains one or more words. In tutoring sessions, there are several parameters that must be constantly monitored by the tutor. These parameters include: (1) the quality of the learner's current Assertion, (2) how much of the topic being discussed has been covered, and (3) the learner's overall ability level for the topic material. AutoTutor is able to monitor these parameters by comparing various combinations of learner and tutor dialogue contributions to specified conceptual bags. To assess the quality of a learner Assertion, LSA matches the learner Assertion against two separate conceptual bags, a bag that contains good answers versus and a bag that contains the bad answers. The higher of the two LSA values is considered the best conceptual match, and therefore, determines how AutoTutor construes the learner's Assertion. For the domain of computer literacy, we have found our application of LSA to be quite accurate and economical in evaluating the quality of learner Assertions [2, 4].

LSA also computes values for two additional parameters, topic coverage and student ability. The LSA topic coverage value is an index that reflects how much of the Ideal Answer has been covered in the tutoring dialogue for a particular topic (e.g., why computers need peripherals). The topic coverage value considers the previous contributions of both the tutor and the learner against a conceptual bag that contains the Ideal Answer. The LSA student ability value is simply an index that reflects the student's ability level within a particular topic. Thus, only the previous student contributions are matched against the Ideal Answer bag [4].

Dialogue Move Generator. AutoTutor has a repertoire of 12 dialogue moves that are controlled by the dialogue move generator (descriptions of these moves are provided in a previous section). They are pump, positive pump, hint, splice, prompt, elaborate, and summarize and five forms of immediate short-feedback (positive, positive-neutral, neutral, negative-neutral, and negative) [4].

AutoTutor's dialogue move generator is governed by 15 fuzzy production rules that primarily exploit data provided by the LSA module. Each fuzzy production rule specifies the parameter values in which a particular dialogue move should be initiated [4].

4. Conclusions

AutoTutor is designed for dialogue conducting in English language. For application of this system in Russian, Lithuanian or other languages it is necessary to replace the existing semantic lexicon with required language, and also to modify or include additional algorithms in the language analyser for the better analysis of applied speech. For application and modification it is also possible to use an existing open-source prototype of GnuTutor [2] above the described program.

It is obvious that intelligent tutoring systems using multi-step structure of a tutoring dialogue and applying different methods of the semantic analysis of student‘s responses shall find wide application in open education system. With their mass application the paradigm of open and distant education will change. According to this paradigm the basic emphasis in development of educational electronic editions will be displaced from electronic textbooks onto electronic intelligent tutors. Character of work of the tutor also will change. The idea to control learners' cognitive activities on the basis of the analysis of learning outcomes has been achieved through the conducting virtual tutoring dialogue with purpose to increase efficiency in mastering knowledge that becomes the main idea of this paradigm.

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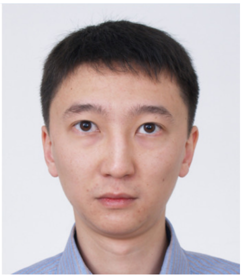

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CUMULATIVE INDEX

COMPUTER MODELLING and NEW TECHNOLOGIES, volume 16, No. 1, 2012 (Abstracts)

D. Greenberg, D. Golenko-Ginzburg. Financial Models of Human Behaviour in Design Office. Part I. Design Office as an Active Player, *Computer Modelling and New Technologies*, vol. 16, No 1, 2012, pp. 7–14.

The problem outlined in the paper refers to the theory of active systems [2] and centres on decision-making to optimally reallocate the award received by the design office, among subordinated PERT-COST projects. The decision-making enables not to have losers among any project entering the design office's portfolio. The design office stands here as an active player.

Keywords: active systems; system's utility; projects of equal and different importance; design office's portfolio; PERT-COST projects; active players

R. Kopitov. Formalization of a Reliable Enterprise Design, *Computer Modelling and New Technologies*, vol. 16, No 1, 2012, pp. 15–29.

The methodology of enterprise's organizational structure formed on the base of the axiomatic approach is analysed in the given research. The proposed methodology allows determining the reliability according to mutual simple conformity of common referential activity to the complete referential process described it.

Keywords*:* enterprise's organizational structure, reference activity, reference process harmonization

Sh. Mirseidova, A. Inoue, L. Atymtayeva. Evaluation of Fair Market Price of Resources in Oil and Gas Industry Using Fuzzy Sets and Logics, *Computer Modelling and New Technologies*, vol. 16, No 1, 2012, pp. 30–34.

Managing the complexity and profit of major projects in today's oil and gas sphere has never been more critical. Against the backdrop of a decline in both global economic conditions and corporate revenues, stakeholders are demanding improved return on investment (ROI), reduced risk and exposure and greater transparency. Since capital construction projects in the upstream oil and gas industry comprise a significant percentage of company spend, there must be a particular focus on predictability, transparency and reliability, including estimation of profit, controlling and reducing the costs associated with these projects. The best opportunity to make a positive impact on the life cycle of capital project in this industry is during early planning, even before the capital outlay occurs. Emphasis should be placed on budget control, approved corporate budget changes and project management internal budget transfers. As the prices of oil and gas fluctuate every day this is the most difficult part of budget control, because even slight changes in the value has a huge impact on overall financial situation of project. That's why it will be very convenient to use Fuzzy Logic methodology of Soft Computing to make certain calculations in order to estimate the fair price of resources and remove the uncertainty of non-clear boundaries of oil price.

Keywords*:* oil and gas industry, Fuzzy Sets and Logic, oil price, gas price, FRIL, intellectual system, management of resource effectiveness

D. Shynybekov, G. Bektemyssova, A. I. Kuandykov. Decision-Making on the Basis of Group Methods for Systematisation and Project Choice, *Computer Modelling and New Technologies*, vol. 16, No 1, 2012, pp. 35–39.

Exact wording of the decision-making task in space of the relative scale of measurement is provided. the methods and algorithms of solution of the above mentioned task are presented.

Keywords: decision making, project management

Zh. Ya. Omarova. A Numerical Simulation of Hydrodynamics Low-Concentrate Solutions, *Computer Modelling and New Technologies*, vol. 16, No 1, 2012, pp. 40–44.

A mathematical model of a low-concentrate salt solution movement in a closed curvilinear field is considered. Results of model's numerical calculations in natural variables by the method of fictitious areas are presented. Received graphs demonstrate the salt solution circulation in the selected field.

Keywords: concentration, method of fictitious areas, convergence

COMPUTER MODELLING and NEW TECHNOLOGIES, 16. sējums, Nr. 1, 2012 (Anotācijas)

D. Greenberg, D. Golenko-Ginzburg. Cilvēku izturēšanas dizaina birojā un to finanšu modeļi. 1. daļa. Dizaina birojs kā aktīvs dalībnieks*, Computer Modelling and New Technologies,* 16. sēj., Nr. 1, 2012, 7.–14. lpp.

Problēma, ieskicēta rakstā, attiecas uz aktīvo sistēmu teoriju [2] un lēmumu pieņemšanas centriem, lai optimāli pārdalītu balvu, ko saņēmis projektēšanas birojs, starp padotajiem PERT-COST projektiem. Lēmumu pieņemšana ļauj zaudētājiem starp jebkuriem projektiem neiekļauties Tehniskās nodaļas portfelī. Projektēšanas birojs šeit ir kā aktīvs dalībnieks.

Atslēgvārdi: aktīvās sistēmas; sistēmas lietderība; vienlīdzīgas un dažādas nozīmes projekti, dizaina biroja portfelis; PERT-COST projekti; aktīvi dalībnieki

R. Kopitov. Uzticamu uzņēmuma projektu noformēšana, *Computer Modelling and New Technologies,* 16. sēj., Nr. 1, 2012, 15.–29. lpp.

Dotajā pētījumā ir analizēta uzņēmuma organizatoriskās struktūras metodika, kas veidota, pamatojoties uz aksiomātisko pieeju. Ierosinātā metodika ļauj noteikt ticamību saskaņā ar kopējas norādošas aktivitātes savstarpēju vienkāršu atbilstību pilnam norādošam procesam, kas to apraksta.

Atslēgvārdi: uzņēmuma organizatoriskā struktūra, atsauce aktivitāte, atsauce procesu saskaņošana

Š. Mirseidova, A. Inu, L. Atimtajeva. Naftas un gāzes industrijas resursu godīgas tirgus cenas novērtēšana, lietojot Fuzzy rindas un loģiku, *Computer Modelling and New Technologies,* 16. sēj., Nr. 1, 2012, 30.–34. lpp.

Pārvaldot sarežģītību un lielo projektu peļņu šodienas naftas un gāzes jomā nekad nav bijušas kritiskākas. Pret krituma fonu gan globālos ekonomikas apstākļos, gan korporatīvos ieņēmumos, ieinteresētās personas pieprasa uzlabotas atdeves ieguldījumos (ROI), samazinātu risku, kā arī iedarbību un lielāku pārredzamību. Tā kapitālās būvniecības projekti iepriekšējā naftas un gāzes nozarē ietver ievērojamu daļu no uzņēmuma patēriņa, ir jābūt īpašai koncentrēšanās uz prognozējamību, pārredzamību un uzticamību, tostarp novērtējot peļņu, kontroli un samazinot izmaksas, kas saistītas ar šiem projektiem. Vislabākā iespēja, lai padarītu pozitīvu ietekmi uz kapitāla projekta dzīves ciklu šajā nozarē ir agrīnā plānošana, pat pirms rodas kapitāla izdevumi. Uzsvars būtu jāliek uz budžeta kontroli, apstiprinātiem uzņēmuma budžeta grozījumiem un projektu vadības iekšējiem budžeta transformējumiem. Tā kā naftas un gāzes cenas svārstās katru dienu, šī ir budžeta kontroles vissmagākā daļa, tādēļ, ka vismazākās vērtības izmaiņas atstāj milzīgu ietekmi uz visu projekta finansiālo stāvokli. Tādēļ būtu ļoti ērti lietot *Fuzzy Logic Soft Computing* metodoloģiju, lai veiktu konkrētus aprēķinus, lai novērtētu resursu godīgu cenu un novērstu naftas cenas neskaidro robežu neprecizitātes.

Atslēgvārdi*:* naftas un gāzes nozare, Fuzzy rindas un Logic, naftas cena, gāzes cena, intelektuālā sistēma, vadības resursu efektivitāte vadīšana

D. Šainibekovs, G. Bektemisova, A. I. Kjandikovs. Lēmumu pieņemšana, pamatojoties uz grupu metodēm sistematizācijai un projektu izvēlei, *Computer Modelling and New Technologies,* 16. sēj., Nr. 1, 2012, 35.–39. lpp.

Rakstā tiek sniegts lēmumu pieņemšanas uzdevumu precīzs formulējums mērījuma relatīvas skalas jomā. Tiek doti iepriekšminētā uzdevuma risinājuma metodes un algoritmi.

Atslēgvārdi: lēmumu pieņemšana, projektu vadība

Ž. J. Omarova. Vājas koncentrācijas šķīdumu hidrodinamikas skaitliskā simulācija, *Computer Modelling and New Technologies,* 16. sēj., Nr. 1, 2012, 40.–44. lpp.

Dotajā rakstā tiek izskatīts zemas koncentrācijas sāls šķīduma kustības slēgtā līklīniju laukā matemātiskais modelis. Tiek doti rezultāti par modeļa skaitlisko aprēķinu dabīgajos mainīgos ar fiktīvu jomu metodi. Saņemtie grafiki pierāda sāls šķīduma cirkulāciju izvēlētajā jomā.

Atslēgvārdi: koncentrācija, fiktīvu jomu metode, konverģence

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4. ***Articles*** should be Times New Roman typeface, single-spaced.
5. The article should include:
   - title;
   - author's name(s) and information (institution, city, country, the present address, phones, and e-mail addresses);
   - abstract (100-150 words);
   - keywords (max. 6);
   - introduction – clear explanation of the essence of the problem, previous work, purpose of the research and contribution;
   - description of the research;
   - conclusion section (this is mandatory) – should clearly indicate the advantages, limitations and possible applications;
   - references.

   Attention! First name, last name, the title of the article, abstract and keywords must be submitted in the English and Latvian languages (in Latvian it is only for Latvian authors) as well as in the language of the original (when an article is written in different language).
6. The text should be in clear, concise English (or other declared language). Please be consistent in punctuation, abbreviations, spelling (***British English***), headings and the style of referencing.
7. ***The title of the article*** – 14 point, UPPERCASE, style Bold and centred.
8. ***Author's names*** – centred, type size 12 point, Upper and lower case, style Bold Italic.
9. ***Author's information*** – 10 point, Upper and lower case, style Italic, centred.
10. ***Abstract and keywords*** – 8 point size, style Normal, alignment Justify.
11. ***The first level Headings*** – 11 point, Upper and lower case, style Bold, alignment Left. Use one line space before the first level Heading and one line space after the first level Heading.
12. ***The second level Headings*** – 10 point, Upper and lower case, style Bold, alignment Left. One line space should be used before the second level Heading and 1/2 line space after the second level Heading.
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14. ***Text*** of the article – 10 point, single-spaced, alignment Justify.
15. The set of ***formulas*** on application of fonts, signs and a way of design should be uniform throughout the text. The set of formulas is carried out with use of editors of formulas MS Equation 3.0 or MathType. The formula with a number – the formula itself should be located on the left edge of the text, but a number – on the right one. Font sizes for equations are the following: 11pt – full, 7pt – subscripts/superscripts, 5pt – sub-subscripts/superscripts, 16pt – symbols, 11pt – subsymbols.
16. All ***Figures*** – must be centred. Figure number and caption always appear below the Figure, type size 8 point.

   Figure 1. This is figure caption

   Diagrams, Figures and Photographs – must be of high quality, in format *.TIFF, *.JPG, *.BMP with resolution not less than 300 dpi. Also formats *.CDR, *.PSD are possible. Combination of Figures in format, for instance, *.TIFF with elements of the in-built Figure Editor in MS Word is prohibited.
17. ***Table Number and Title*** – always appear above the Table. Alignment Left. Type size 8 point. Use one line space before the Table Title, one line space after the Table Title and 1/2 line space after the Table.

Table 1. This is an example of a Table

Heading	Heading	Heading
Text	Text	Text
Text	Text	Text

18. ***References*** in the text should be indicated by a number in square brackets, e.g. [1].
References should be numbered in the order cited in the manuscript. The correct format for references is the following:

Book: Author(s). (Year of publication). *Book title (in Italics)*. Place of publication: Publisher.
Example: 1. Kayston, M. and Fried, W. R. (1969). *Avionic Navigation Systems.* New York: John Wiley and Sons Inc.

Conference Proceedings: Author(s). (Year of publication). Title of an article. In Conference name, Date (Page range). Place of publication: Publisher.
Example: 2. Canales, Romero J. (2003). A First Step to Consolidate the European Association of Aerospace Students in Latvia (Presented by the Munich Local Group). In 'Research and Technology – Step into the Future': Programme and Abstracts. Research and Academic Conference, Riga, Latvia, April 7–11, 2003 (pp. 20–29). Riga: Transport and Telecommunication Institute.

Journal article: Author(s). (Year of publication). Article title. *Journal Title,* Volume(issue), range of pages. DOI.
Example: 3. Nikora, V. (2006). Hydrodynamics of aquatic ecosystems. *Acta Geophysica,* 55(1), 3–10. DOI:10.2478/s11600-006-0043-6.

Report: Author(s). (Year of publication). *Title*. Place of publication: Publisher. (Report number)
Example: 4. Osgood, D. W., & Wilson, J. K. (1990). *Covariation of adolescent health problems.* Lincoln: University of Nebraska. (NTIS No. PB 91-154 377/AS).

Government publication: Institution name. (Year of publication). *Title.* Place of publication: Publisher.
Example: 5. Ministerial Council on Drug Strategy. (1997). *The national drug strategy: Mapping the future.* Canberra: Australian Government Publishing Service.

19. ***Authors Index***
Editors form the author's index of a whole Volume. Thus, all contributors are expected to present personal colour photos with the short information on the education, scientific titles and activities.

20. ***Acknowledgements***
Acknowledgements (if present) mention some specialists, grants and foundations connected with the presented paper. The first page of the contribution should start on page 1 (right-hand, upper, without computer page numbering). Please, paginate the contributions in the order they are to be published. Use simple pencil only.

21. ***Articles poorly produced or incorrectly formatted may not be included in the proceedings***