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MATHEMATICAL AND COMPUTER MODELS OF SCIENTIFIC NOTIONS

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Abstract. *Supra, the authors proposed independent computer interactive presentation of notions (without using other languages). In this method, feedback confirms mastering of the notion. Such presentation may be “with avatar” or “without avatar”. They developed mathematical and computer models for some verbs, nouns and adjectives, proposed new classification of verbs and new “grammar” for notions. They with coauthors implemented some notions of Kyrgyz and English on computer. In the paper mathematical models for some notions in various sciences are described. It can be used for further development of such computer presentations and learning languages.*

Key words: *mathematical model, language, computer model, relation, independent presentation, learning.*

ИЛИМИЙ ТҮШҮНҮКТӨРДҮН МАТЕМАТИКАЛЫК ЖАНА КОМПЬЮТЕРДИК МОДЕЛДЕРИ

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Аннотация. *Буга чейин авторлор түшүнүктөрдүн компьютерде көз карандысыз түрдө (башка тилдерди колдонбостон) чагылдырылышын сунушташкан.*

Бул ыкмада компьютер өз тарабынан колдонуучу аталган түшүнүктү өздөштүргөнүн тастыктайт. Мындай аракет "аватардык" же "аватардык эмес" түрдө болушу мүмкүн. Авторлор кээ бир этиштердин, зат атоочтордун жана сын атоочтордун математикалык жана компьютердик моделдерин иштеп чыгышты, этиштердин жаңы классификациясын жана түшүнүктөрдүн жаңы “грамматикасын” сунушташты. Авторлоштору менен бирге алар кыргыз жана англис тилдериндеги айрым түшүнүктөрдү компьютерде чагылдырууну ишке ашырышкан. Бул макалада ар кандай илимдердеги кээ бир түшүнүктөрдүн математикалык моделдери баяндалат. Аталган жыйынтыктарды түшүнүктөрдү компьютерде көз карандысыз чагылдыруу ыкмасын өнүктүрүүгө жана тилдерди өздөштүрүү үчүн колдонууга болот.

Ачкыч сөздөр: *математикалык модель, тил, компьютердик модель, байланыш, көз карандысыз чагылдыруу, өздөштүрүү.*

МАТЕМАТИЧЕСКИЕ И КОМПЬЮТЕРНЫЕ МОДЕЛИ НАУЧНЫХ ПОНЯТИЙ

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Аннотация. Ранее авторы предложили независимое компьютерное представление понятий (без использования других языков). По этому методу, обратная связь подтверждает, что пользователь овладел понятием. Такое представление может быть «аватарным» или «неаватарным». Авторы разработали математические и компьютерные модели для некоторых глаголов, существительных и прилагательных, предложили новую классификацию глаголов и новую «грамматику» для понятий. Вместе с соавторами они реализовали некоторые понятия кыргызского и английского языков на компьютере. В статье описаны математические модели для некоторых понятий в различных науках. Это может быть использовано для дальнейшего развития таких представлений и изучения языков.

Ключевые слова: математическая модель, язык, компьютерная модель, отношение, независимое представление, обучение.

1. Introduction

The general task of present-day informatics is developing of interactive computer presentations of known or invented real and virtual objects to offer the user the opportunity to master them safely and effectively before real treating. If such computer presentation does not depend on the user's knowledge and skills on similar objects then we call it independent. Such presentations are more effective because the user can learn without referencing other objects in mind. In regards with learning a language, the user begins to thinking in it, without translation in mind.

Survey. Earlier, investigating and learning a living language were implemented with the assistance (including bilingual dictionaries and text-books) of persons who had a complete command of it. Invention of recording sounds gave possibility to fix examples of an oral language objectively. Invention of talking pictures fixed examples of phrases with connection to situations and actions. Computer games gave the user the opportunity to choose actions with corresponding phrases. Existing software to learn languages base on languages native to the user, nevertheless some notions are presented independently. This survey demonstrates that there were not completely independent presentations of natural languages before our publications.

Using ideas [1-3] we [4-10] gave definitions and developed elements of such presentations. Some scientific notions are described in [11] and [12]. We shall consider also feedback for checking-up knowledge. We propose to use random generation of tasks and situations for independent presentation of notions and objective estimation of understanding level.

2. Definitions for independent presentation

Definition 1. If low energetic outer influences can cause sufficiently various reactions and changing of the inner state of the object (by means of inner energy of the object or of outer energy entering into object besides of commands) at any time then such (permanently unstable) object is an affectable object, and such outer influences are commands. A system of commands such that any subject can achieve desired efficiently various consequences from other one is a language.

Hypothesis 1. A human's genuine understanding of a notion can be clarified by means of observing the human's actions in real life situations corresponding to this notion.

Remark. Simple mathematical models consist of fixed (F_i) and movable (M_j) sets and temporal sequence of conditions of types ($M_j \subset F_i$), ($M_j \cap F_i = \emptyset$), ($M_j \cap F_i \neq \emptyset$). More complex models include transformations of sets (see below).

Computer interactive presentations are built on the base of mathematical models.

Definition 2. Let any notion be given. If an algorithm acting at a computer: generates (randomly) a sufficiently large amount of instances covering all essential aspects of the *notion* to the user, gives a command related to this notion in each situation, perceives the user's actions and performs their results clearly on a display, detects whether a result fits the command, then such

algorithm is said to be a computer interactive presentation of the notion.

Certainly, commands are to contain other notions too. But these words must not give any definitions or explanations of the notion.

Definition 3. If all words and actions being used in Definition 3 are unknown to the user nevertheless s/he is able to fulfil the meant action (because it is the only natural one in this situation) then the notion is said to be primary. If the user has to know supplementary words to complete the action then the notion is said to be secondary. Thus, there arises a natural hierarchy of notions.

Using this method, we can present not only real notions (objects and actions) but also notions which have imaginary concepts.

Hypothesis 2. A person learning a natural language without references to any other ones, hearing a notion in various situations begins to form a kind of mathematical model in mind corresponding to this notion by means of trial and error method and attempts to fulfill operations similar to mathematical ones: closing and compactification. After successful completing such operations, the human feels “mastering” this notion.

Hypothesis 3. Any notion has a minimalistic mathematical model (involving minimal number of entities in Occam’s sense).

3. Models for some scientific notions

For uniformity and convenience of the user.

Background is in the spectrum from white till black; sometimes chess color (light grey and dark grey) for 2D-spaces is used.

Avatar object (A-object) is green. Function, or result of A-object is red and is denoted as F-object below. Target for F-object is yellow and is denoted as T-object below.

Approaching T-object is accompanied by signals of "hot-cold" type too. Tracks of A-object (light green) and F-object (light red) can also stay while 2D-motion.

Example 1. Solving of the equation $F(x) = 0$. A-point can move along the abscissa axis only. T-object is the abscissa axis.

Example 2. Searching for $\min F(x)$. A-point can move along the abscissa axis only. T-object is gradient of yellow color down.

Example 3. Solving of the system of equations $F(x, y) = u$, $G(x, y) = v$ (firstly, linear ones; the user discovers linearity). A-point is (x, y) , F-point is (F, G) , T-point is (u, v) .

Example 4 [12]. Solving of the equation $\sqrt{z} = w$ for complex numbers. The origin $z = 0$ repels A-point. The user discovers the following: to reach T-point going around the origin is necessary.

Notions (measures) as invariants.

Example 5. Length of a curve. A-object with F-object is a red curve with the leading green endpoint. While pulling its length preserves. T-objects are several curves of various lengths. The user is to detect the T-object with corresponding length and pull A-object on this T-object.

Example 6. Area of a figure. A-object with F-object is a red rounded figure with the green boundary. While pulling its area preserves. T-objects are several figures of various areas. The user is to detect the T-object with corresponding area and pull A-object on this T-object.

General example 7 [14]. Presentations of non-Euclidean spaces filled with T-objects and brown Obstacles. The user drives a “green car”, with additional possibilities to put marks etc. The screen is the windshield of the car. The task is to find and erase T-objects without breaking Obstacles.

Examples:

- Möbius band: the user can verify that a right boot left on a street will be met as a left boot after passing half of the street;
- Topological torus is a square with opposite sides glued. (This space used to be discovered by many programmers independently). Motion in arbitrary direction will lead to the initial position someday.
- Riemann surface of the function $\sqrt{z}$, with the third coordinate up.
- Riemann surface of the function $\sqrt{(z^2 - a^2)}$, with the third coordinate up. Passing between two unbreakable pillars only leads to another part of the space.
- Motion with creating the Riemann surface of the implicit function $H(z, w) = 0$, H is a given polynomial. This is the only way to investigate its branching points and general structure.
- Projective plane with the third coordinate up. While motion along the street "trees" on this side move to us as usually but "trees" on the opposite side move from us.
- Presentations for 4D-space filled with 4D-solids. The 3D-coordinates are presented as usually, the fourth coordinate (call it deep) is denoted with continuous darkening of the environment. We look at the space through 3D-slit and can deep and undep. The task is to detect 4D-solids. For instance, the 4D-deep-directed cone is seen as the sequence "little ball" - "enlarging ball" - "none" while motion "deep".

Physics:

Example 8. Trajectory of thrown ball. The red ball (A-object) flies off the gun about 70° to a horizontal yellow line (T-object) with light green track and stops. If the user does nothing then the red ball flies off again. The user is to drag the red ball and continue the trajectory until the yellow line.

Example 9. Center of gravitation of a triangle. Given a triangle with horizontal base. "Where must a support be put for equilibrium?"

4. Conclusion

We hope that successful implementation of proposed and other such presentations of mathematical objects would distinguish new essential features of various mathematical objects and be interesting both for programmers and for users regardless their relation to mathematics.

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