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Applying adaptive learning principles for the e-studies

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1. Principles of the adaptive learning

E-learning systems depending on their functionality (functions they are able to perform) can be divided into simple e-learning systems and complex e-learning systems [1]. The subject of this paper is complex e-learning systems. Such systems are also known as adaptive learning systems. They are designed to have possibility to prepare individual learning plans for learners and help learner to choose the best suitable sequence of the learning run (path, created curriculum). System is also able to tell the next task and theme to be learned on the next step, analyze solutions given by learner, tell are they right or wrong. If solution is wrong system analyses why and examines which knowledge learner has not enough to solve the current task. System is able to help to solve problems by giving examples from earlier taught topics, remarking closely related cases.

System brings the knowledge out depending on the goals of the learner, his/her knowledge and other information stored in the learner's model. The learner's model shows what learner had already studied, what he/she already knows and have learned.

System can also initiate interactions between users (other learners) that are online at that moment, using knowledge about other learners stored in their learner model. In this case interaction groups can be created for the problem to be better solved.

The principles of adaptation lay on the ability to: 1) prepare individual learning plans; 2) define the next learning step; 3) analyze solutions given by learner; 4) help to solve problems; 5) use learners model and update it; 6) if needed initiate interactions between users.

2. Learner control in the system

Learning by itself is successful if earlier defined learning goal at the end of the learning is reached. So learning system should operate and direct its actions to the learning goal and learner satisfaction to be achieved. In this case well known finite state machine (FSM) model can be applied. Finite state machine model can be interpreted as Test–Operate–Test–Exit unit in which system comprises at least two goals [2]:

- some means for acting on the environment in order to achieve a goal;

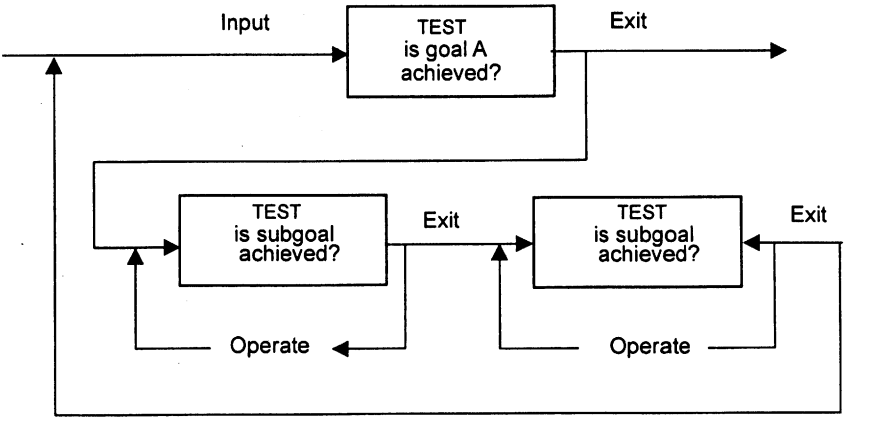

Fig. 1. Vertically coupled TOTE units [2].

- some arrangement for recognizing when actions have achieved a goal.

This system draws knowledge to test whether some goal has been achieved, at which point it exits (stops); it continues testing until the difference between current state and the end point specified by goal has been minimized.

For example (look at the Fig. 1), if the learning goal A is achieved it means that learning process is completed and for the learner it is not needed to test for the sub goals. Vertically coupled TOTE units become as a simple TOTE unit. If it is not, the learner has to be tested for predefined sub goals [2,3].

3. Learner model

The use case diagram [4, 5] of the learner model [3] expresses how the learner model could be created in the learning environment using independent component synchronized with the e-learning platform. Learner model is needed for the purpose of ability to adapt behavior of learning system according to the each learner needs. The main point of creation of learner model is the way in which primary belief the system has about the learner is created.

It is possible to clarify from the Fig. 2 that for the purpose of activating the `create primary belief` use case there are two possibilities: 1) the learner has to come to the consultation with the intellectual component as an output after the standard registration in the e-learning platform or 2) this happens as a condition of selecting next learning steps as an output result of learner intentions to continue the current learning session. When we have the 2nd possibility, `create primary belief` has a meaning of updating the belief the system already has about the learner.

`Create primary belief` use case includes use cases `Ask the learning goal`, `Ask preferred learning style`, `Ask about visualization level`, `Identify knowledge level` that are needed for creating *primary belief*

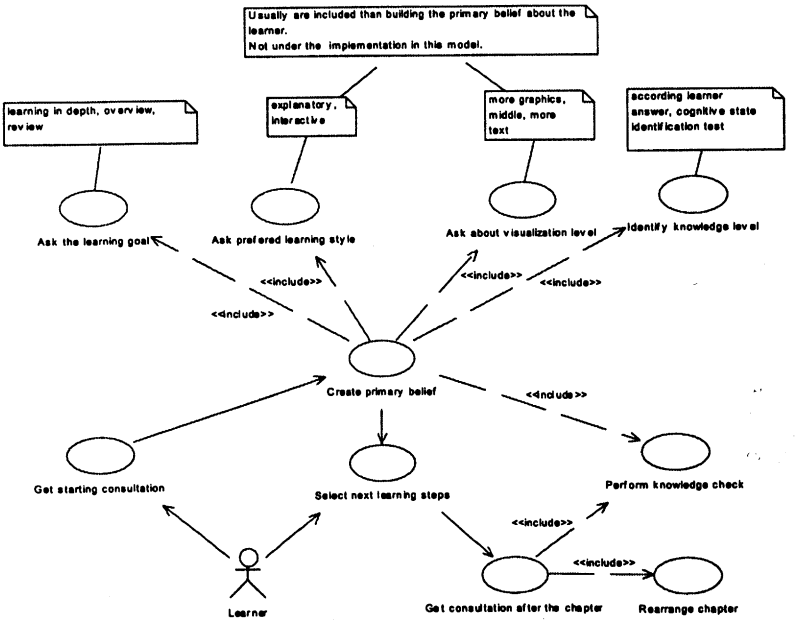

Fig. 2. Learner model use case diagram [3].

in the boundaries of the first possibility we have mentioned above. `Create primary belief` use case also includes `Perform knowledge check` use case in the boundaries of the second possibility we mentioned and has a meaning that results of knowledge check test influence the *belief* the system has about the learner.

After the belief about the learner is created (or updated) it is possible to leave the learning environment or continue learning. This case is expressed with the `select next learning steps` use case. This has a meaning that the learner selects for ex. a next suggested chapter to read. `Get consultation after the chapter` use case expresses the requirement of ability to check the learner's knowledge after some amount of learning material, update the belief and rearrange the chapter material (`Perform knowledge check` and `Rearrange chapter` UC).

4. The adaptation of the system

The main points where adaptation of the system appears [3] are identification of the learning goal, suggesting desired learning style, offering different visualization levels, identification of the knowledge level and only then 1) formulation of curriculum corresponding to the learning goal and having appropriate level and content; 2) edition of the curriculum according to the learner's knowledge level that might change during the learning process.

5. Expert system for ascribing knowledge level of the learner

For the purpose of ascribing learner to the appropriate set of knowledge level expert system can be applied. Our example shows the Jess [6] expert system rules that implement classification of learners to the different knowledge sets that correspond to the number of points they have collected during the testing.

Let E is a universal set, x – an element from the E, and the G – any characteristic. Exact subset A of the universal set E, with elements x with characteristic G, is defined as a set of the ordered pairs [3]

$$A = \{\mu_A(x)/x\},$$

$\mu_A(x)$ – characteristic function that gets value 1, if x has characteristic G, and value 0 in other case.

Because of the many uncertainty appearing when deciding about the knowledge level of the learner, the same task of classification can be implemented applying principles of fuzzy sets theory and using Fuzzy Jess toolkit [7] for its practical implementation.

Fuzzy subset differs from the usual subset in that way that for the elements x from the E there is no particular answer "yes – no" according to the characteristic G. So, fuzzy subset A of the universe E is defined as a set of the ordered pairs

$$A = \{\mu_A(x)/x\},$$

$\mu_A(x)$ – characteristic function of membership (or membership degree) that gets values in the ordered set M (for ex. $M = [0, 1]$).

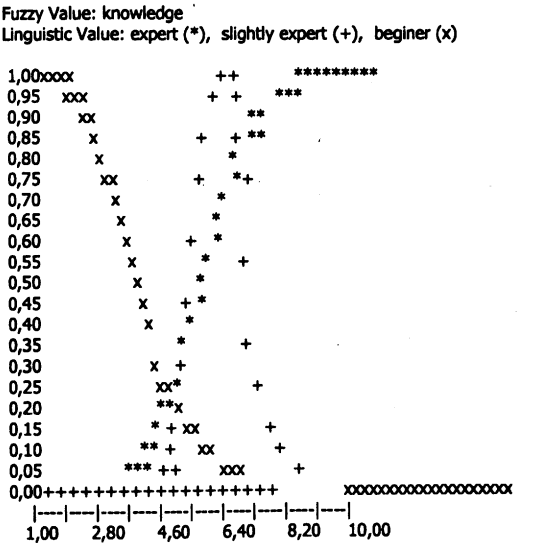

Fig. 3. Fuzzy sets of fuzzy value knowledge, created using fuzzy jess.

Membership function $\mu_A(x)$ shows the degree of membership of element x in the subset A. The set M is called a set of the memberships.

6. Conclusions

1. Main principles of the adaptive learning paradigm are discussed.
2. The way in which the learning progress is managed during the process of learning is presented.
3. Proposed learner model defines the system's knowledge about the learner that is required to adapt the behavior of the system according to the needs of a particular learner.
4. An expert system and a fuzzy expert system as specific tools for the solving of the problem of ascribing learner to the appropriate set of knowledge are suggested and examples are given.

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Adaptyvaus mokymosi principų taikymo galimybės e-studijose

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Straipsnyje aptarti pagrindiniai adaptyvaus mokymo principai, kurie gali būti sėkmingai taikomi e-mokymo sistemose diegiant e-studijų modelį. Mokinio kontrolės mechanizmas yra svarbus elementas sistemoje, atspindintis mokymosi pažangos mokymo proceso eigoje valdymo būdą. Pasiūlytas mokinio modelis nusako ką e-mokymo sistema turi „žinoti" apie mokinį, kad galėtų pritaikyti savo elgesį besimokančiojo reikmėms. Sistemos adaptyvumas akivaizdus tam tikruose modelio taškuose, kurie analizuojami išsamiau ir sudaro bendrą sistemos atliekamų veiksmų vaizdą. Mokymo procese svarbus mokinio žinių lygio nustatymo vaidmuo bei sistemos nuomonės suformavimo apie duotą mokinį mechanizmas. Žinių lygio nustatymui ir mokinio priskyrimui į tam tikrą žinių lygio aibę kaip priemonė pasiūlytos ekspertinės sistemos ir neraiškios ekspertinės sistemos.