Modelling, simulation, animation in e-learning courses

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Content

Abstract

Computer animation and simulation models of complex processes and events, which are the matter of the instruction, can be an effective didactic application. Gaining deeper knowledge about the objects modelled help planned simulation experiments oriented on processes and events researched. Animation experiments realized on multimedia computer can aid to easier understanding of dynamic processes and to uncover their essential properties.

Visualization of simulation experiments on computer has a great significance in teaching/learning process. Animation helps not only to increase the illustrative ness but it also allows to acquire new knowledge for students based on own observation and own experience of the work with the model.

Key words: Electronic learning material, animation, interactivity, audiovisual presentation, multimedia information and communication technologies, virtual learning environment.

Introduction

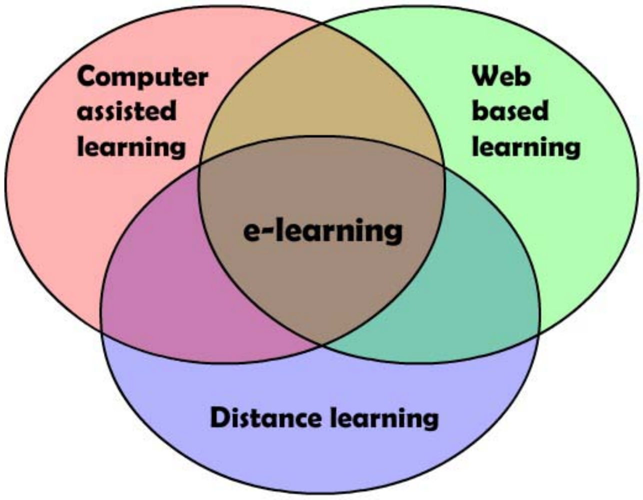
The information society based on knowledge has several characteristic features. There are: the globalisation, decentralisation, e-communication, re-qualification, life-long learning, e-learning etc. In life-long learning, re-qualification and other modern education forms has a mean roll the electronically and with information and communication technologies supported learning and teaching. The simple and every day accessed Internet becomes to be suitable universal information source for education. Many universities, schools and other educational institutions have an extra server for teaching material presentation and also for management of distance study courses. The management and control of distance study programs and their courses are often integrated in Learning Management Systems (LMS) (Serafín, 2002; Kočíková, 2007; Kočíková-Štefková, 2007, Chráska, 2007).

E-learning

E-learning is very often used as a name for electronically elaborated source supported learning. The content of term e-learning is not exactly defined. The written form of them is also not standardised. In literature we can found it in several forms: e-learning, E-learning, e-Learning, elearning and eLearning. We prefer the form of "e-learning", because the prefix "e-" is the short form for "electronic" or "electronically supported" and this form is acceptable for several language lexicology.

E-learning is not equals with distance learning, because it is possible to realise it not only a distance way. It also is not equals with computer assisted learning, because it is possible to realise it by mobile telephone or using other tools. E-learning can be realised not only as a distance study but also can be used in present form of study. On the picture 1 is demonstrated the relations among web-based learning, e-learning, distance learning and computer assisted learning. In extended mean e-learning includes all education forms supported by electronically elaborated learning materials but in reduced mean it includes only the web based by LMS realised learning.

Picture 1: Relations among web-based learning, e-learning, distance learning and computer assisted learning



Electronic Textbooks

Electronic textbooks as teaching aids may be used in all forms of education. Even though they are created for e-learning, they may also be a good source of knowledge and information for attendance and combined schooling. As well as this, they may possibly be a useful and effective helper in learners' individual work. The term *e-learning* is commonly used with *e-teaching* inasmuch as it is always needful to see the authors behind the electronic presentation and the e–textbook. Just a linear text in digital form cannot be considered an electronic textbook. Neither can a text structured in a hierarchical manner or a book assorted in chapters and subheads. (Elek, 2001; Hambalík-Elek–Tóth, 2000). An electronic text-book, barring the general requirements needed for a good text-book, should also meet other requirements following from general theory and psychology of teaching and also from current possibilities how to present the course of study by means of a computer.

These are mainly:

- Encouragement and providing for an active cooperation with educatee.
- Providing for a reciprocal feedback – educatee reacts to stimuli in the presentation, but the programme retroacts too at educatee's intervention and activity.
- Where it is necessary and appropriate, simulation models are used as for presenting new knowledge, so for experimentation with the model in order to gain experience and new knowledge.
- In the textbook should be found a sufficient amount of inspiration and problem tasks to be solved, but also exemplary resolved problems to be studied and analysed.
- Teacher's pedagogical mastery as a creator of the presentation is reflected in the didactic transformation of the contents of teaching: an adequate formulation and expression of thoughts, structure, arrangement and the way of presenting new knowledge as well as conducting of educatee and optimisation of his or her advancement (Borsuková– Gabaľová, 2008).
- A textbook should be adaptable as much as necessary, it should respect an individual way of study of educatee. It should thus provide not only for an individual rate of study, but also for an individual style.

Creation of didactic multimedia presentations for e-learning

The creation of didactic multimedia applications for e-learning is usually a team work. Such a team consists of the specialists in pedagogy and psychology, the representatives of subject knowledge – teachers, and the programmers - experts in realisation means and environments with the corresponding skills of the usage of these means and environments in the creation of presentations (Lányi, 2000).

The creation of didactic applications consists of several steps:

1. Specification of the topic, extend and content of teaching, gathering the materials together (collecting the materials), fundamental for the presentation, pictures, schemes etc.
2. Specification of the target group and recognition of their abilities.
3. Preparation of the textual part with necessary didactic transformation, transformation of the schemes and pictures into the adequate form, preparation of the sound sequences, choice of mathematical models that will be a part of the application, specification of visualization of the outcome of simulation experiments, specification of necessary animations etc.
4. Specification of the structure of presentation, connection of particular information items and units, dynamics of particular windows (projection of pictures, texts, presentation of sound sequences etc.)
5. Choice of realisation means based on the possibilities they offer and on the possibility of realisation of determined aims and goals according to the target group.
6. Adaptation and modification of steps 3 and 4 according to chosen realisation means.
7. Realization: Implementation of particular fragments in case of the design from bottom upward. Preparation of control part gradually adding particular information wholes in case of the design from above downward. The processes can be combined. The important part is the clear structure of the presentation.
8. Testing of the system in fictional conditions and then in real conditions.
9. Elimination of insufficiencies, taking into account the comments and suggestion of the users and also own experiences from the work with the application.

Creation of didactic multimedia presentations has an iterative character and the steps can be cyclically repeated. Didactic software has to support all the phases of teaching-learning process: motivation, presentation of new information and knowledge, practice and fixation of new habits and skills and specification of the level of acquired knowledge (testing). These phases should be cyclically repeated and interchanged.

Steps 1-4 and 6 are the role of the teacher. The teacher determines what has to be done and how it should look like and work. The way of realization and the realization itself is the role of programmer. These are the steps 5 and 7. All the other steps are necessary to realize in close cooperation of both groups of realization team teachers and programmers. It is welcome and advantageous, when all the steps are fulfilled by one "universal creator". The teacher cannot appropriately fulfil his role without necessary information and knowledge about realizations means and environments that enables him to specify his requirements to the realisation (Szőköl, Š. – Tóth, K. 2007). The process of creation can be compared with the creation of software applications. The analogy of both is obvious.

It is necessary to realise that computer-supported teaching applies the basic principles of programmed teaching specified by Skinner. These, however, have to be actualised and modified for multimedia computer-supported e-learning.

- Electronic lesson consists of information items, which are presented in adequate batches.
- After certain batches of information follows the practice with feedback.
- Items of information are mediated in various forms so that more senses are involved into the internalisation of knowledge at a time – multimedia presentation is used.
- Active cooperation of a learner has to be ensured and fostered.
- Feedback is well supported – a learner responds to the stimuli from the presentation but also the programme adequately responds to the activities of a learner.
- Simulation models are used in necessary and appropriate situations – for presentation of new knowledge as well as for the experiments with the model to achieve own experiences.
- Pedagogic mastery of a teacher (creator of presentation) is reflected in didactic transformation of a content of teaching: appropriate formulation and expression of ideas, structure, organisation, and the way of presentation of new knowledge and also managing the learner and optimisation of his/her procedures.

Structure of didactic applications

Structure of didactic multimedia application emerges from hypertext structures. The difference is that the information wholes connected into unified structure have different character. Information units which form the information items and which are interconnected into hyper-structure by hyperlinks can be: text, sound sequence, music, picture, animation, graph, etc.

The basic hyper-structures are: linear, hierarchic, screen, web and net (combined). When to use which structure is presented in information source (Stoffová, 1999; Tulipán, 2006). Chosen structure at the particular level has to emerge from the structure of teaching material. This has to be arranged into certain structure and should help to systematise the knowledge. Therefore the author of scenario of didactic application has to choose the structure of presentation with certain amount of pedagogic mastery.

Many psychologists consider the human long-term memory associative. That means that in human memory, particular information items are by associations connected. Therefore the elaboration of the structure of the presentation is regarded as a very important part of the creation.

The basic principles of elaboration of structure of didactic multimedia applications can be compared with structured programming. Information whole at higher hierarchic level can become information element at particular resolution level.

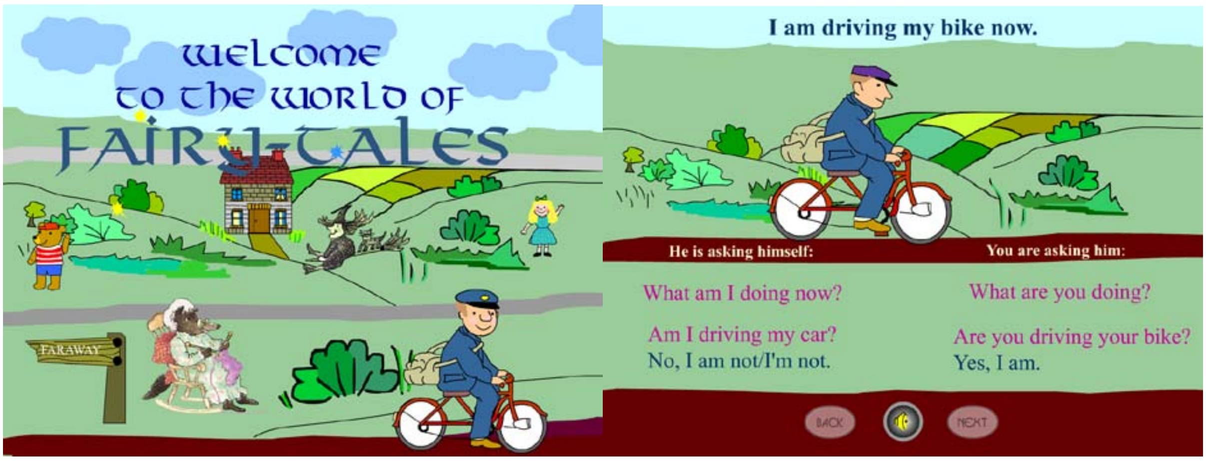
Animations in Electronic Presentations and in Electronic Text-books

Animation is commonly understood as a sequence of pictures created on a computer by way of an animation programme. The pictures are shown one by one the way they give the impression of a continuous motion. Such a classical understanding of animation has been adopted from animated cartoon technology. This definition is also valid for many animation sequences that are used in didactic applications. Many of them make the teaching material more dynamic and used for interactivity between subject and object of educational process and also support and keep the interest of participants.

1. Animation for illustration

Animation for illustration and revival of presentation increases the illustrative ness and makes active the learning process. Such animations usually only accompany the text of electronic textbook that deals with the content of teaching. Animation can be accompanied with short text sequences that comment on the animation (describe particular parts of moving picture) and/or sound sequences explaining the animation. These sequences can be activated automatically when the concrete part of animation is presented or at the movement of mouse etc. Into this group belong, for example, interactive animated fairy-tales, language applications, live picture multimedia dictionaries to widen the vocabulary (Lib, 2005, Walat, 2005) etc.

Picture 2: Illustrative animation in an English language textbook for elementary schools



Particular objects in this kind of applications move spontaneously or they can be manipulated. For example, the clock can be set up, the stories are brought to life on the screen of computer, scene is dynamic, the characters move, etc. The action on the screen is accompanied with live word and/or the story is with credits. Such an animation, mainly the illustrative animation, can be replaced by video-recorder sequences.

Illustrative animation is used in electronic fairy tale books or in textbooks for children. One example of illustrative animation we can se in picture 2 which contains two pages (title page and one common page) of one English language text book for elementary schools in Slovakia. The presented application is result of a diploma work elaborated at Constantine The Philosopher University in Nitra (Líšková, 2003). The application contains the language materials by curricula for the elementary school teaching.

2. Animation for illustration the basic principles

Animation may represent basic principles of functioning of an apparatus, which serve to increase clearness and to revive the process of learning. Such animations supplement only the text of an electronic textbook, showing usually the contents of teaching. Animation may also be supplemented with short text sequences that comment on the animation (its individual parts of a moving picture) and/or audio sequences that explain what the animation stands for, that is to say, what is on the screen and pouncing what educatee should focus on. These sequences can be made active automatically at representing a concrete phase of animation, by a movement of mouse or by clicking on an active element of the scene and suchlike (Gabaľová, 2008;).

Animation to represent basic principles of functioning is mostly used to explain what how works and how it functions. Such animations may have a **schematic character**. It means that real objects do not have to be its component. Real objects are substituted with their schematic representation. For instance, if we want to explain the functioning of a computer, it is sufficient to draw a functional scheme, for example, in terms of functional blocks according to van Neumann's concept and show how input information can be transformed into output. It is satisfactory to explain basic principles of functioning of a computer in terms of functional blocks. However, if we want to be more precise and talk in more detail, we shall change resolving level and draw the structure of individual functional units. As elements of functional units of a computer system shall behave addressable memory cells, different registers and other functional units. For example, at this level it is possible to demonstrate the realization of an instructive cycle for individual instructions of the processor. From individual instructions of the processor, it is possible to realize different operations at highest level, for example, addition of two whole numbers, possibly building the whole arithmetic of fixed and floating decimal point.

Picture 3: The animation of main principles of microscope in physic e-textbook

For an illustrated animation, in many cases it is possible to use a functional model or a prototype of mechanism. Sometimes in order to observe the dynamics of the system with the unaided eye, diminishing the real object suits the purpose. In order to observe the real objects and processes with the unaided eye, it is oftentimes inevitable to enlarge them. In case of the processes that are relatively slow in the real world, there is a need for deceleration for didactic purposes. There is also a whole succession of processes that run so fast that the human eye is not able to monitor the changes. Therefore, it is essential to decelerate their representation.

The animations described above, mainly the animation to illustrate the presentation, can be substituted by a video-recorder sequences or by a sequence of pictures that can be projected at any speed; even possibly step by step. Such animation sequences have also been used in classic textbooks that represented particular phases of motion of a body. For example, in the textbooks of Physics, to represent the position of the object we shall need the projection of the object at the position and state time (values of the independent variable). In order to explain the functioning of a four-stroke motor, we shall use a sequence of pictures showing particular phases (strokes) of its operation.

Animations in multimedia didactic applications contribute not only to increase clearness of teaching, but also to convey a quick and correct understanding of dynamic phenomena, natural relations and principles of ongoing processes that are the subject of teaching/learning.

Animations in multimedia applications may fulfil different tasks.

Picture.4: The animation of main principles of space vision

3. Animation to explain dynamic phenomena

Animation explains dynamic phenomena that are the subject of research have to be based of their mathematical models. In this place we usually work with simulative time. It means these are deceleration and acceleration respectively of the phenomena observed, though the visualization may be in progress in real time too. A mathematical model of such systems is commonly expressed with a system of (differential) equations and various sophisticated functional dependences (Šafařík- Štofová-Cvik, 1981). For example, observing the trajectory of a body at operated movements, observing a chemical reaction dependent on time and so on (Feszterová, 2007).

Time is always an independent variable. (In this case the animation could also be substituted by a video-record, though it would still be bound by the values of the parameters it has been recorded at.) A computer model of a real system enables experimentation with the model and thus realization of the animation guided by parameters of the experiment (Stoffa- Stoffa, 2004).

4. Animation as visualization of numeric results

In this case the animation is quantification of qualitative indicators. It is simply an observation of the values of quantities that resulted from measurement (it is oftentimes an indirect one) and that are not to be observed with the unaided eye. For instance, conductivity of a semiconductor under certain circumstances, flow course at a certain point in electrical circuit, state of a computing process realized on a computer, pressure development in hydraulic system and suchlike. In such cases time does have to be an independent variable. This animation is also guided by parameters of the model and therefore, representation is dependent on factual results (Tomanová, 2002). Very often the result of experiment is presented as an X-Y graph (in case of 2D presentation) or as an X-Y-Z graph (in case of 3D presentation).

5. Controlled animation

Controlled animation is an animation when the motion of object(s) is guided by parameters of the object's mathematical model. Animation stands for a real behaviour of the system in controlled conditions. An operated animation is ordinarily connected with the simulative computer model of the system that has been defined on the object of observation (Stoffová, 1994; Stoffová, 1995; Stoffová, 2004).

As an example of controlled animation we give the animation of body, which was thrown (fired) from the ground. The motion (trajectory) of such body in the Earth gravitation field is called projection at an angle. A body which was thrown (fired) under evolutional angle α with absolute initial speed v_o moves along trajectory. For a closer look how this works, we can use a simple model, which, to a certain extent, idealizes this situation and makes the visualization of body trajectory in the flat possible. It means, this supposes the body movement in the flat and does not provide the system, which is applied on an object (body) with the simulation of outer environmental influence. (e. g. the strength and direction of wind, rain, snowing etc.).

We apply the following relations for horizontal and vertical coordinates of object position in the flat:

$$x_{0x} = v_0 \,.\, \cos(\alpha) \qquad x_{0y} = v_0 \,.\, \sin(\alpha) \qquad \textbf{(1)}$$

The calculation of the maximum height of a shot:

$$H = (v_0^2 \,.\, \sin(\alpha)^2) / 2g$$

The time of flight: $t_D = (2.\ v_0 \,.\, \sin(\alpha)) / g$ **(2)**

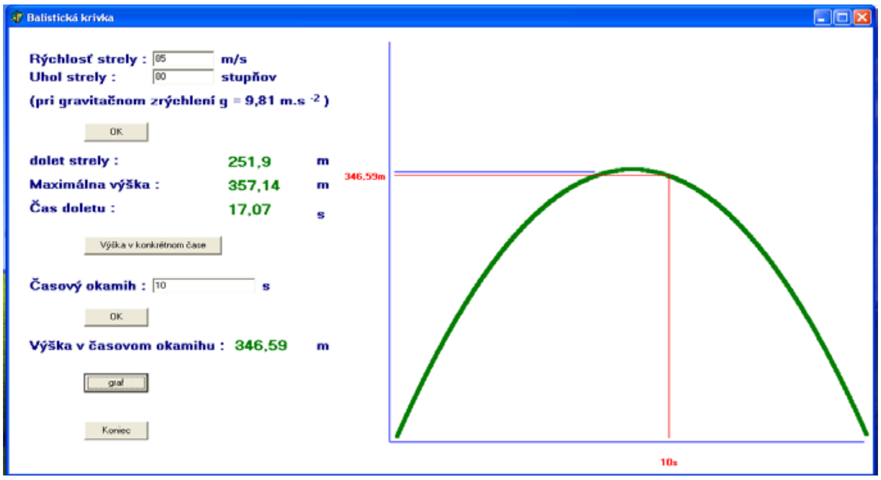
The height obtained at any moment

on time axis within the interval $(0, t_D)$: $h(t) = v_0 \,.\, t \,.\, \sin(\alpha)^2) - (g \,.\, t^2) / 2$

In preceding formulas *g* is gravitational acceleration, which in the program, has value 9,81 m. s^{-1}.

Putting relations (1) and (2) into the program makes it possible to create simulated model with the graphic output experiment results. Figure 3 demonstrates result of such experiment for concrete values v_0 = 85 m/s and α 80 degrees.

Picture5: Result of experiment for v_0 = 85 m/s and α = 80 degrees



In the case of a spatial model of body movement in the Earth's gravitation field we apply the following equation, which describes general body movement.

$$m\ddot{\vec{r}} = m\vec{g} + \vec{f} \qquad \vec{f} = \left(f_x,\ f_y,\ f_z\right) \qquad \vec{f} = \frac{\vec{F}_v}{m} \tag{3}$$

If we consider also influences of the environment in which an object moves, we have to include influence of winds and the resistance of environment into relations describing position parameters of an object. In a real situation the wind's influence upon an object depends on its speed, weight and shape. The higher the speed of a shot compared with the speed of wind, the less is the force of wind influencing the shot. After solution in this way modified systems of equations we can became the following expression for coordinates of object position in the space for time t:

$$x(t) = x_0 + v_{xv}t + \frac{mv_{x0}}{\kappa}\left(1 - e^{-\frac{\kappa t}{m}}\right)$$

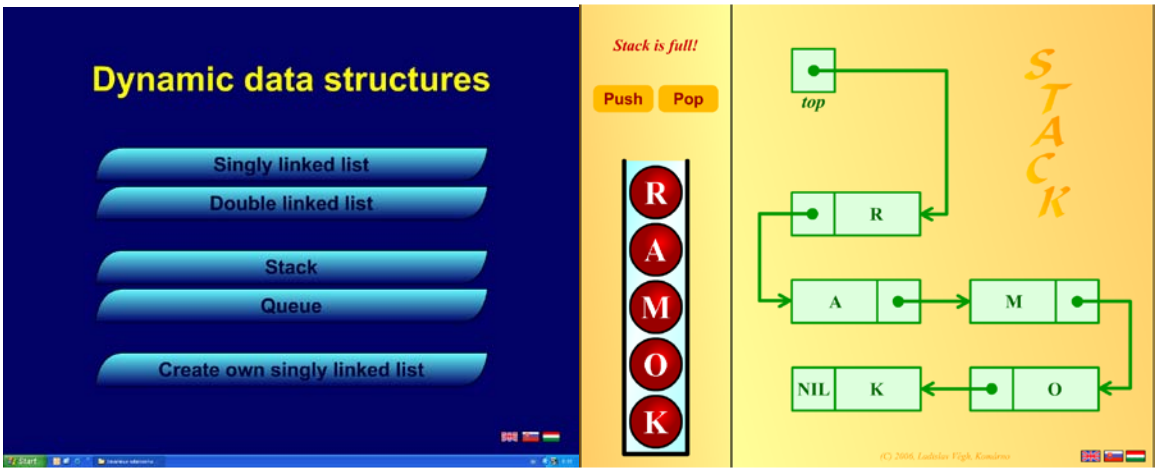
$$y(t) = y_0 + v_{yv}t + \frac{mv_{y0}}{\kappa}\left(1 - e^{-\frac{\kappa t}{m}}\right) \tag{4}$$

$$z(t) = z_0 + v_{zv}t + \left(\frac{mv_{z0}}{\kappa} + \frac{m^2 g}{\kappa^2}\right)\left(1 - e^{-\frac{\kappa t}{m}}\right) - \frac{mg}{\kappa}t$$

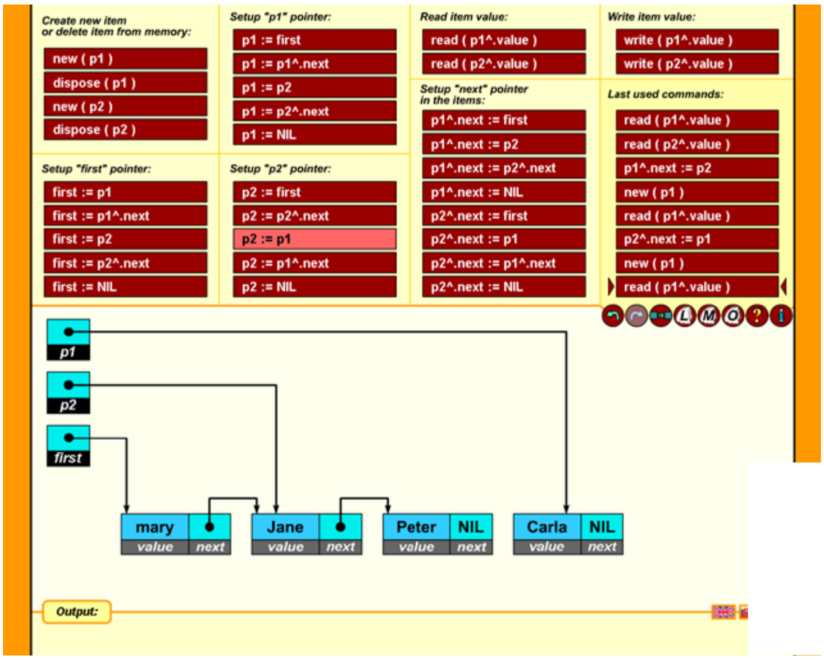
Given equations were used to create the simulation model which scans trajectories of a body fired by certain initial speed, under certain angle, with concrete direction and speed of wind and influence of given wind conditions. Wind conditions (fog, snowing) are described by the coefficient of the environmental density.

Another examples of interactive animation models are applications in form of problem oriented interactive editors. This application allows the user to create, rebuilt a model in interactive way during experiments with them. Into this category of models we can include the application introduced on the picture 6 for explain and work with dynamic data structure (Stoffová – Végh, 2006; Végh, 2006a; Végh, 2006b). The dynamic data structures editor was implemented at Computer Science Department of J. Selye University in Komárno. Similar editors we can found on Internet as a freeware.

Picture.6: The animation system of dynamic data structure



Picture 7: The interactive animated dynamic data structure editor



In the picture 6 we can see the animation system of dynamic data structure. The left side picture shows the first screen of the system with the main menu and communication language selection. The right side picture shows the work with stack. In the picture 7 is demonstrated The interactive animated dynamic data structure editor.

Conclusion

Animation has a significant position in didactic multimedia computer applications used for e-learning. Animations are an important part of interactive electronic textbooks and therefore besides the illustrative function it has to fulfil also the other functions that originate in the basic attributes of e-learning. They have to be carrier of useful information according to the object of teaching and they also have to interactive and controllable. Controllability of an animation does not mean only the possibility of activation, acceleration or deceleration of presented picture sequences but mainly the control of presentation (depiction) of objective reality. However, the creation of parameter-controlled animation in popular graphic environments such as Flash, Dream Weaver, etc. is not directly supported. Creation of animation of this kind requires professional programmer approach, which comes out of mathematical model of studied process. Such an animation needs computer implementation of mathematical module that enables the user (learner) to realise interactive computer experiments with the model to acquire new information or solutions of given problems. To realise this kind of models we were helped by graphic libraries compatible with the programmer environments (e.g., we used the graphic library in Delphi).

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