© Strojniški vestnik 48(2002)7,395-403
ISSN 0039-2480
UDK 004.42:004.5
Predhodna objava (1.03)

© Journal of Mechanical Engineering 48(2002)7,395-403
ISSN 0039-2480
UDC 004.42:004.5
Preliminary paper (1.03)

Gradnja uporabniškega vmesnika na temelju programskega paketa MATLAB za študij sistemov

Building a User Interface Based on MATLAB for Control System Studies

Martina Leš - Boris Aberšek

Sodobna programska oprema ponuja visoko interaktivno kakor tudi učinkovito učno okolje za učenje teorije sistemov in simuliranj za mnoga področja študija tehnike. Predstavljeni prispevek opisuje razvoj in izvedbo učnega pripomočka za učenje teorije linearnih sistemov, ki povezuje skripta v elektronski obliki s primeri v Matlabu in Simulinku prek grafičnega uporabniškega vmesnika za obe različici Matlaba: 5 in 6. To je grafična uporaba, ki daje študentom dodiplomskega študija pregleden in preprost pripomoček pri učenju teorije linearnih sistemov v maternem jeziku. Študentom daje osnovo za samostojno učenje in učenje na daljavo. V prispevku smo se posebno posvetili predstavitvi grafičnega vmesnika in njegove strukture, kar smo ponazorili še s primerom. Na koncu smo opravili še analizo uspešnosti različnih metod poučevanja z računalnikom.

(Ključne besede: teorija linearnih sistemov, Matlab, orodja učna, vmesniki grafični, vmesniki uporabniški)

Software technology provides a highly interactive and powerful learning environment for system theory and simulation in some engineering disciplines. This paper describes the development and implementation of an educational tool for linear systems theory that connects electronic manuscripts with examples in Matlab and Simulink through a graphical user interface for versions 5 and 6 of Matlab. This is a graphical application that offers undergraduate students additional support by presenting linear systems theory in their native language. It provides students with a foundation for independent studies and distance learning. The main focus in this paper is given to the graphical interface structure, which is illustrated with an example. We conclude the paper with an analysis of different computer-assisted learning methods.

(Keywords: linear systems theory, Matlab, teaching tools, graphical user interfaces)

0 UVOD

Programska industrija ponuja dandanes učinkovita učna okolja za učenje različnih tehničnih vsebin. Poučevanje teorije sistemov je zapleten postopek, saj le-ta vsebuje veliko količino teoretičnega znanja in matematičnega ozadja. Posledica tega je, da se je velikega dela teorije sistemov zelo težko učiti brez vizualizacije. Vizualizacijo in simbolično računanje je mogoče opraviti v Matlabu, ki je interaktivni programski jezik za izvedbo znanstvenih in inženirskih izračunov, in izhaja iz *laboratorija za delo z matrikami* (Matrix laboratory). To pomeni, da večina operacij temelji na matričnih postopkih. Matlab ponuja tudi grafično okolje za izdelavo grafičnih uporabniških vmesnikov (GUV), ki omogoča gradnjo prijaznejšega okolja za uporabnika programov – lastnih uporabniških vmesnikov, pripomočkov in predstavitev. Uporabniški grafični vmesnik lahko pripomore pri organizaciji in omogoča

0 INTRODUCTION

The software industry provides a powerful learning environment for different engineering disciplines. The teaching of systems theory is a complex process because it contains a lot of theoretical knowledge and has a mathematical background. As a consequence, many concepts that are involved in systems theory are difficult to learn without visualization. The visualization and the symbolic computations can be done in MATLAB™, which is an interactive programming language for scientific and engineering computation, based on a matrix laboratory (Matrix laboratory). This means that most operations are organized as matrix operations. Matlab also provides a graphical user interface (GUI) tool, which makes it more user friendly and allows advanced users to build their own interfaces, tools and visual presentations. A GUI can help to organize and provide easier access to examples and additional

lažji dostop do primerov in dodatnih uporab. Veliko število Matlabovih orodij nam daje sicer zelo dobro podporo pri reševanju različnih problemov, sintakse se je mogoče z lahkoto naučiti, toda veliko število funkcij (in število se nenehno povečuje) že povzroča neučinkovito uporabo. Da bi se izognili temu problemu, je treba skrbno organizirati primere in jih dobro dokumentirati. To je bila tudi osnovna zamisel, zaradi katere smo se lotili gradnje uporabniškega vmesnika, ki povezuje dodatno še skripta v elektronski obliki (predavanja in računalniške vaje).

V zadnjem desetletju so mnogi avtorji predstavili posamezne predmete, zapise in eksperimente z uporabo računalnika [1]. Mnogi uporabljajo World-Wide-Web kot servis za medmrežje in brskalnike (naprimer Internet Explorer ali Netscape) za navigacijo. Nekateri avtorji so predstavili tudi delo z virtualnimi inštrumenti, kakor npr. LabView ([2] in [3]), drugi spet simulacijska in animacijska orodja ([4] do [6]), toda le redki so predstavili program za celotni predmet ([7] in [8]). Večinoma je to posledica zelo obsežnega dela, ki je potrebno za pripravo takih predmetov.

Ker sestavljajo osnovo teoriji sistemov teoretična in matematična predznanja, je velik del teh zelo težko razumeti brez vizualnih predstavitev, je bilo izdelano orodje za študente dodiplomskega študija, ki se praktično prvič srečajo z Matlabom, bodo pa nadaljevali s študijem tehnike in simuliranj. S tem smo pokrili najprej samo vse področje teorije linearnih sistemov. Uporabniški vmesnik in okolje smo pripravili v taki obliki, da ga je mogoče razširiti na podobne predmete.

1 POUČEVANJE TEORIJE LINEARNIH SISTEMOV

Tradicionalno poučevanje teorije linearnih sistemov poteka prek predavanj, v katerih učitelj razlaga teorijo in demonstrira tipične rešitve nekaterih primerov. Študentje širijo svoje teoretično znanje z računalniškimi vajami, za katere pa je potrebno večje teoretično predznanje kakor tudi matematična podlaga.

Na Univerzi v Mariboru so bila izdelana različna orodja, ki so jih uporabljali tudi študenti (npr. LSD, PADSIM, ASSO), saj so bila pripravljena v maternem jeziku. Razlog za uporabo drugih programskih jezikov, kot npr. Matlab, LabView, MatCad in drugih je bil v velikem razvoju in širitvi njihovih zmogljivosti, kakor tudi v njihovem poenotenju in vedno večji standardizaciji in splošni uporabi (tudi v industriji). Vedno več pozornosti pri regulacijah in simuliranjih dandanes posvečamo Matlabu in Simulinku, posledica pa je veliko primerov in funkcij, ki so na voljo v zadnjih letih.

applications. Many of Matlab's toolboxes offer a lot of support for different problems. It is easy to learn Matlab's syntax, but the number of designed functions is still increasing and this can lead to ineffective use. To overcome this problem, the examples should be well organized and documented. This was the basic idea: to build an additional user interface with links to manuscripts (lectures and computer exercises) in electronic form.

In the last ten years, many computer-based engineering courses, curricula and experiments have been presented [1]. Many of them use the World Wide Web as an Internet service and software interfaces (e.g. Microsoft Explorer or Netscape Navigator) for navigation. Some authors emphasize the use of virtual instrumentation, such as LabView ([2] and [3]), others use simulation and animation tools ([4] to [6]), but only a few complete courses have been presented ([7] and [8]). Mostly, this is a consequence of the extensive work needed for the preparation of the courses.

Systems theory consists of a lot of theoretical knowledge and a mathematical background. As a consequence, many concepts involved in control systems theory are difficult to understand without visualization. The Linear Systems Theory Education Tool is designed for undergraduate engineering students, who are generally working with Matlab for the first time, and will continue with engineering and simulation studies. It covers the full Linear Systems Theory course. The interface and the environment are organized in such a way that they can be extended to similar courses.

1 TEACHING CONTROL SYSTEMS THEORY

Traditionally, control systems theory is taught by a lecturer, who explains the theory and demonstrates typical solutions for some problems. The students broaden their theoretical knowledge with computer exercises, which require a lot of theoretical knowledge and a mathematical background.

At the University of Maribor some special control systems education tools, LSD, PADSIM, ASSO, prepared in Slovene, have been used in exercises. Another reason for using computing languages such as Matlab, LabView, or MatCad is the rapid development of different technical computing languages, their uniformity and use in many industrial applications. Increasing attention in control engineering has been given to Matlab and Simulink. As a result, many examples and functions have been prepared in recent years.

2 PROGRAMSKO ORODJE IN TEHNIČNI RAČUNALNIŠKI JEZIK

Računalniška simuliranja, simbolično računanje in vizualizacijo lahko naredimo z uporabo Matlaba. Ta interaktivni programski jezik omogoča preprosto odkrivanje napak, njegova orodja pa ponujajo veliko podpore inženirskemu delu. Študenti pri vajah pripravijo simuliranja in poiščejo rešitve v Matlabu za različne naloge s pomočjo učitelja ali demonstratorja. Ugotovili smo, da je tak postopek sprejemljiv za študente, čeprav imajo študenti probleme z novo sintakso in veliko količino funkcij in postopkov. Seveda je omejitev tudi licenčnina za Matlab, kar pa lahko same uredijo izobraževalne ustanove.

Naprednejši uporabniki lahko zgradijo lastne uporabniške vmesnike, pripomočke in vizualne predstavitve z uporabo grafičnega uporabniškega vmesnika (GUV) v Matlabu, toda med vajami jih ne uporabljamo zaradi pomanjkanja časa in poznavanja programskega jezika.

Matlab in njegove uporabe so pripravljeni v angleškem jeziku. Za inženirje je neizogibno, da uporabljajo angleščino, toda uporaba tujega jezika lahko povzroči dodatne probleme pri posameznih študentih zaradi napačnega razumevanja slovnice ali pomoči. Zelo pomembno je tudi, da dajemo karseda veliko informacij v maternem jeziku. Največ kar lahko pri tem naredimo je, da izdelamo uporabniški vmesnik v slovenščini. Tako omogočimo študentom natančnejše učenje, ki je zaradi tega tudi veliko lažje.

3 UČENJE Z UPORABO RAČUNALNIKA IN ORODJE ZA TEORIJO LINEARNIH SISTEMOV

Sodobne učne metode izpostavljajo pomembnost posameznega študija, ki mora biti kolikor je mogoče avtonomno, dejavno in prilagojeno posameznikom. Da bi lahko ponudili tak študij, moramo ponuditi poleg knjig še veliko različnih virov. V zadnjem desetletju je bilo veliko novih zamisli in metod predstavljenih v okviru študija na daljavo. Elektronski viri, na primer skripta v elektronski obliki ali uporabe z računalniško podporo lahko naredijo študij zanimivejši, toda veliko bolj pomembno je uporabljati nove tehnologije in neprestano prilagajati znane metode. Tako je predstavljeno orodje pripravljeno za študente dodiplomskih programov tehničnih smeri. Orodje povezuje dvoje skript v elektronski obliki in veliko število primerov, izdelanih v Matlabu in Simulinku prek grafičnega uporabniškega vmesnika.

Slika 1 prikazuje prehod med tradicionalnim učenjem na računalniško podprtim učenjem, ko nekatere vire uporabimo v elektronski obliki. Povezavo med knjigami pripravljenimi v elektronski obliki, in računalniškimi vajami udejanimo z uporabniškim vmesnikom, ki hkrati omogoča uporabo mnogih drugih uporab, npr. pomoč, vizualizacijo in dodatne opise snovi. Predlagamo, da predavanja še vedno obdržijo glavno vlogo pri izobraževanju.

2 A PROGRAMMING TOOL AND TECHNICAL COMPUTING LANGUAGE

Computer simulations, symbolic computations and visualization can be done in Matlab. These interactive programming languages allow for easy debugging and their toolboxes give a lot of support for engineering. The students prepare simulations or find solutions for different tasks using Matlab with the support of the teacher and a demonstrator. Students find this approach quite acceptable, although they need to acquaint themselves with new syntax and many new functions and principles. However, there are some limitations in their use because the students need to have access to Matlab software. This can be arranged by educational institutions.

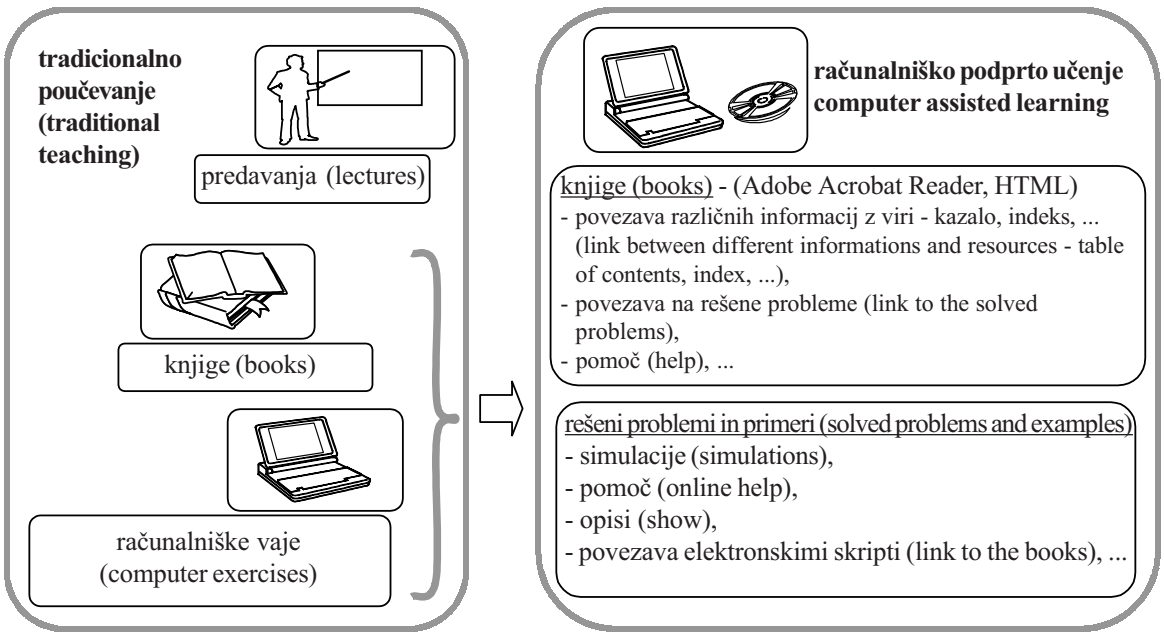
Advanced users can build their own interfaces, tools and visual presentations using the GUI in Matlab, but the GUI normally remains unused during the courses because of a lack of time and a lack of programming-language knowledge.

Matlab and all its applications use English. Therefore, it is necessary for the engineers to use English, and this can cause other problems for some students who misunderstand the grammar or the help. For this reason it is very important to provide as much information as possible in the students' native language. What we can do is to build a user interface in Slovene. This gives the students the possibility to learn more exactly and much more easily.

3 COMPUTER-ASSISTED LEARNING WITH THE LINEAR SYSTEMS THEORY EDUCATION TOOL

Contemporary teaching methods emphasize the importance of individual studies, which should be as much as possible autonomous, active and adapted to the individual. To provide such studies, many different sources, in addition to the books, should be available. In the last decade, distance learning has provided many new ideas and methods. Electronic sources, such as electronic manuscripts and computer-assisted applications, can make studies more interesting, but it is very important to use new technologies and adopt modern methods. The Linear Systems Theory Education Tool is designed for undergraduate engineering students. This tool connects electronic manuscripts and many examples in Matlab and Simulink through a GUI.

Figure 1 presents the transition from traditional to contemporary computer-assisted learning, where some media can be organized in electronic form. The connection between books prepared in electronic form and computer exercises can be realized through a user interface, which also provides the use of many other applications, such as help, visualization and additional descriptions. We expect that lectures will keep their main role in education.



Sl. 1. *Tradicionalno učenje in računalniško podprto učenja: razvoj s pomočjo uporabniškega vmesnika*
Fig. 1. *Traditional learning and computer-assisted learning: the further development provided by a user interface*

Grafični uporabniški vmesnik, izdelan v Matlabu. smo prvotno izdelali le z namenom, da bi povezali primere v celoto. Zatem smo sledili zamislim o študiju na daljavo in glede na to je nastalo orodje za učenje teorije linearnih sistemov.

4 GRAFIČNI UPORABNIŠKI VMESNIK

Predstavljeno grafično orodje za učenje teorije linearnih sistemov je sestavljeno iz glavnega navigacijskega izbora in štirih glavnih grafičnih enot: podizborov za navigacijo po poglavjih, pomoč, predstavitev (tutoriali) in grafično okno. Dodatno smo pripravili še pomoč v pisno-povezovalnem jeziku (PPJ) HTML (Hyper Text Markup Language) in povezavo s skripti, spremenjenimi v elektronsko obliko. To grafično okolje daje predstavitev in pomoč v Matlabovih standardnih oblikah, ki so le malenkostno prilagojene (npr. navigacija in vznikajoči izbori so dodani v slovenščini). Na sliki 2 vidimo glavne strukture predstavljenega grafičnega vmesnika (GUV).

GUV je zgrajen tako, da je mogoča sprememba v druge jezike v glavnem le s preprostim prevodom komentarjev. Orodje je mogoče poljubno razširiti na dodatna poglavja in primere, pri čemer nas omejujejo le možnosti izvedbe znotraj Matlaba in zmogljivost računalnika. Učinkovitost grafičnega vmesnika je povečana z uporabo Matlabove kode p, kakor tudi z uporabo večmedijskih in drugih pripomočkov učenja na daljavo prek medmrežja. Vse našteto omogoča prihodnje dograjevanje.

Dokumentacija za PPJ HTML (pomoč) in skripta so v elektronski splošni prikazovalni obliki (SPO) PDF (Portable Document Format) kot samostojni uporabi. Vse skupaj je povezano v enotno uporabo (sl. 3).

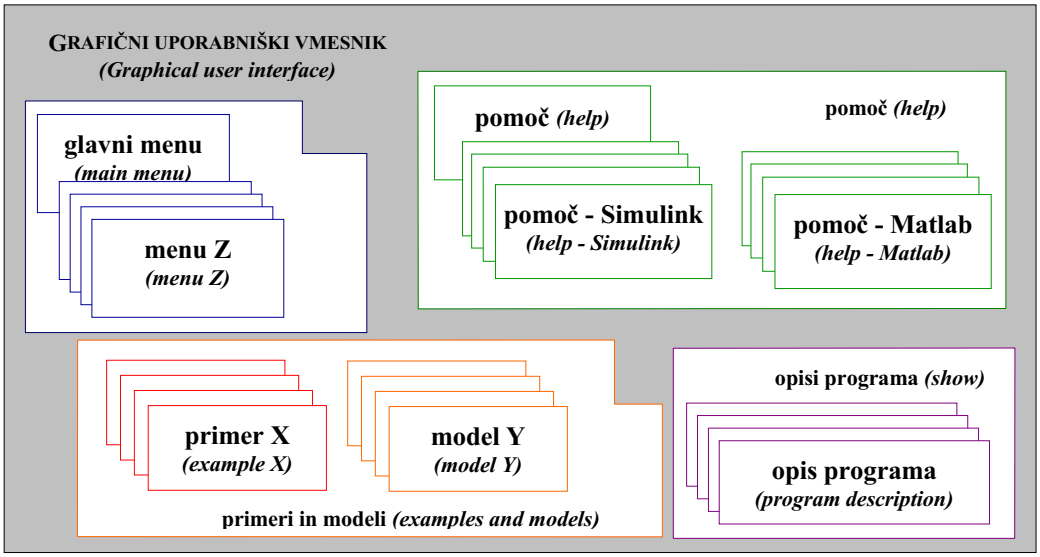
A GUI was prepared in Matlab. First, it was only designed to provide a connection between computation examples and simulations. Following the new ideas from distance learning a more comprehensive Linear Systems Theory Education Tool was developed later.

4 GRAPHICAL USER INTERFACE

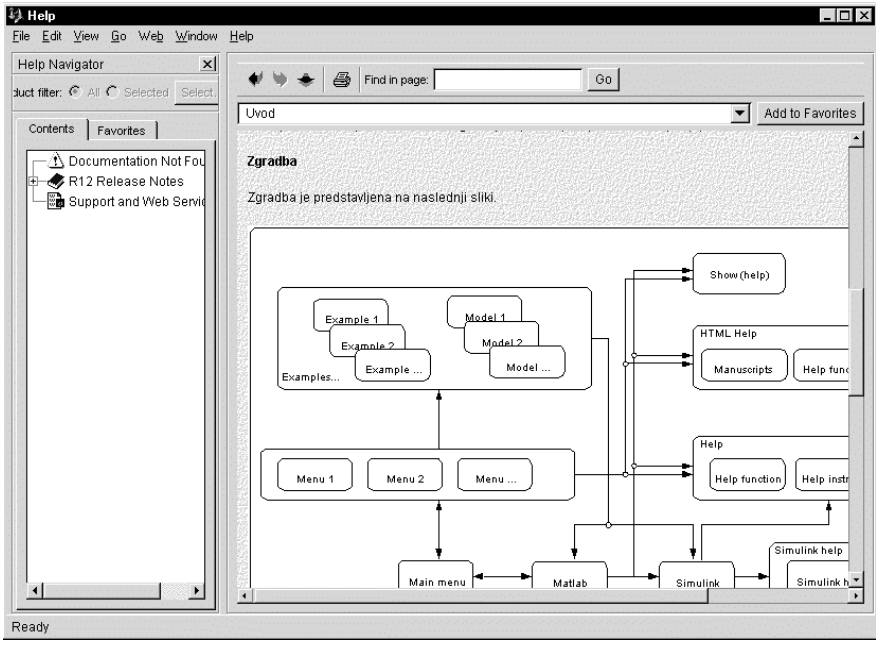
The Linear Systems Theory Education Tool consists of a main navigation menu and four main graphic units: submenus for navigation through chapters, help, show (tutorials) and a graphic presentation window. Additionally, HTML-help and connections to electronic manuscripts are prepared. This graphical environment provides show and help in Matlab standard forms, they have only been changed in some details (e.g. navigation controls and pop-up menus are supplemented in Slovene). Figure 2 presents the main structures of the presented GUI.

The GUI was built in such a way that changing to another language only requires a simple translation of the comments. This tool is also easy to expand to an arbitrary number of topics and examples, and is only limited with the realization possibilities in Matlab and the computer's capacity. The effectiveness of the user interface is improved by the use of Matlab's p-code as well as multimedia and distance-learning capabilities from the during World Wide Web, for future developments.

HTML documentation (Help) and electronic manuscripts in PDF are self-dependent applications. However, they are connected through a GUI with Matlab help (Figure 3).



Sl. 2. *Grafični uporabniški vmesnik – osnovne strukture*
Fig. 2. *Graphical user interface – four main structures*



Sl. 3. *Dokumentacijav PPJ HTML (v Matlabovem oknu za pomoč)*
Fig. 3. *HTML documentation (browsed in the Matlab Help-window)*

5 STRUKTURA UPORABNIŠKEGA VMESNIKA

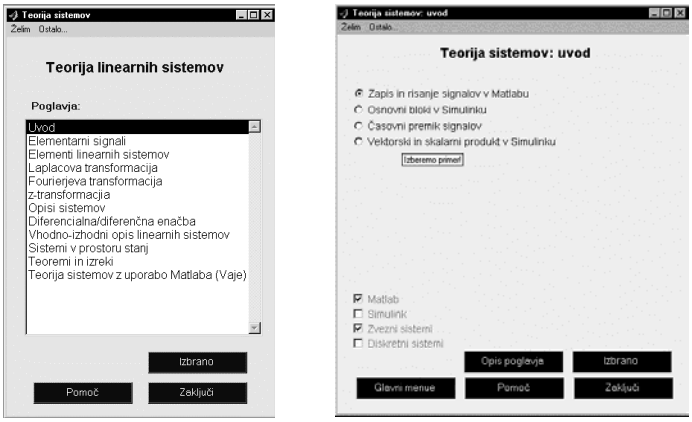
Osnovni izbor omogoča preprosto navigacijo skozi poglavja. Vsako poglavje je samostojna neodvisna enota v lastnem standardiziranem oknu, ki uporablja skupno masko, toda z različnimi lastnostmi (sl. 4).

Iz vsakega okna je mogoč preprost dostop do Matlabove pomoči s kazalom na vsebino teorije linearnih sistemov. Kolikor je le mogoče, so vse operacije standardizirane – tako npr. prikazovanje signalov (sl. 5), pomoč in opisi poglavij – tako imenovani prikaz (sl. 6).

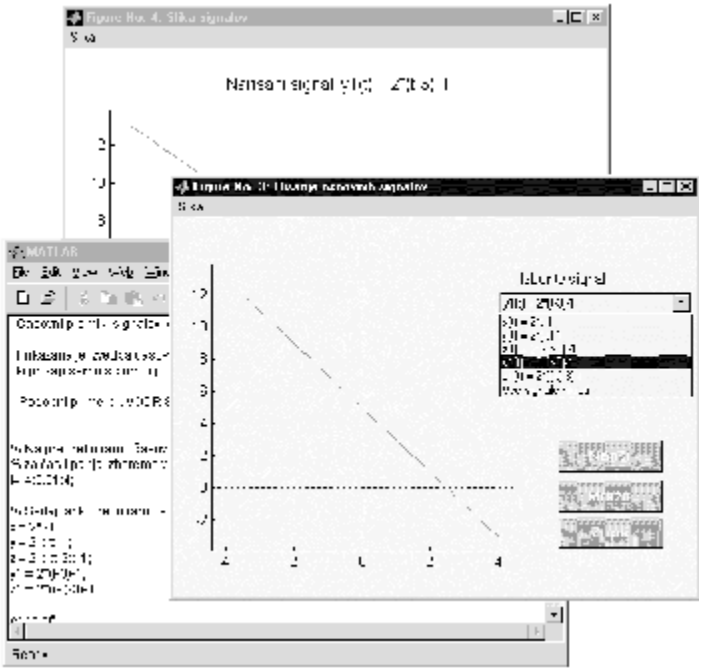
5 USER INTERFACE STRUCTURE

The main menu allows for simple navigation through the chapters. Each chapter is an independent unit with its own standardized window, using the same mask but different properties (Figure 4).

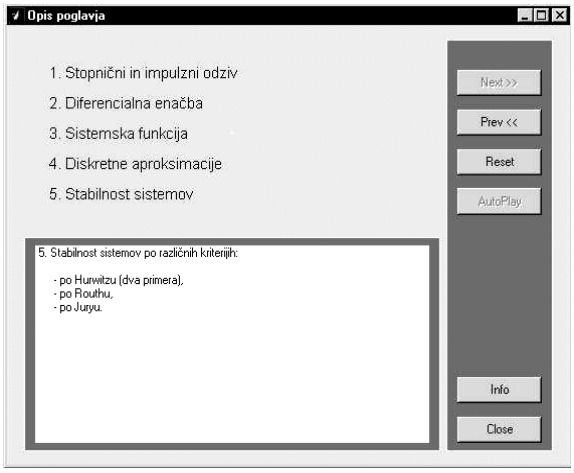
From each window, easy access to the Matlab help with a table of contents of Linear Systems Theory is possible. The tasks are also standardized as much as possible, these tasks include signals visualization (Figure 5), help and chapter descriptions, see (Figure 6).



Sl. 4. *Glavni izbor in izbor za poglavje Uvod*
Fig. 4. *Main menu and menu for chapter Introduction*



Sl. 5. *Grafični prikaz rezultatov je mogoče prenesti v standardno grafično okno (za primer v delovnem oknu)*
Fig. 5. *Graphic window could be exported to the standard graphic windov (for example in main window)*



Sl. 6. *Pomoč v Matlabovem prikazu*
Fig. 6. *Help provided by Matlab show*

6 DOKUMENTACIJA IN SKRIPTA V ELEKTRONSKI OBLIKI

Običajno uporabljamo pomoč v Matlabu s klicem pomoči v Matlabovem delovnem prostoru: *help ime_funkcije*. Ta oblika je skromna, zaradi tega sta mogoči še dve dodatni obliki pomoči: pomoč in prikaz (razširitev demonstracijskega dela Matlaba). Matlabova pomoč omogoča interaktivne povezave, prikaz pa je razširjen tudi še z vizualizacijo. Študentom smo omogočili uporabo obeh oblik.

Dodatno smo dve knjigi – teorijo in vaje – deloma prevedli v PPJ HTML, v celoti pa v SPO vrste PDF. Dodali smo nekatere dodatne operacije: povezave na poglavja, slike, pomembnejše ključne besede in slike. S tem smo uredili skripta v primernejšo obliko, primernejšo tudi za študij na daljavo.

7 PRIMER

V tem poglavju bomo prikazali uporabo orodja za teorijo linearnih sistemov skupaj z dokumentacijo pri določanju stabilnosti sistema po Routhovem kriteriju.

Izberemo poglavje: Matematični modeli in zatem Routhov kriterij. Že iz izborov je razvidno, da lahko izbiramo med primeroma za zvezne in diskretne sisteme, vendar le v Matlabu (ostala dva gumba: Matlab in Simulink ostaneta siva). Ko zaženemo program s funkcijo Routh (ki smo jo sami dodali) z gumbom Izbrano, dobimo naslednji izpis v glavnem oknu.

```
% Stabilnost po Routhovem kriteriju (VhodIzhodRouth)
% Opis funkcije in delovanje ...
% Dodatni primeri: ROUTH, VHODIZHODROUTHD
% Zvezni sistem s karakteristično enačbo:
KE = [1 4 5 2];
CharactEqn = poly2sym(KE,'x')
CharactEqn =
x^3+4*x^2+5*x+2
%  Funkcija Routh daje naslednji rezultat:
R = Routh(KE)
Routh =
  [   1,   5]
  [   4,   2]
  [ 9/2,   0]
  [   2,   0]
Sistem je stabilen!
Polynom =
   x^3+4*x^2+5*x+2
RouthTable =
  1.0000    5.0000
  4.0000    2.0000
  4.5000         0
  2.0000         0
```

6 DOCUMENTATION AND ELECTRONIC MANUSCRIPTS

Usually, Matlab help is retrieved from the workspace by typing the *help function_name*. This form is very poor, thus, two additional help applications can also be used: Matlab-help and Matlab-show (enhancement of Matlab-demo). Matlab-help provides interactive help with links and Matlab show also provides enhanced visualization. We give the students both possibilities: we have prepared help using both applications.

Additionally, two Systems Theory books, theory and exercises, have been rewritten and transferred into HTML and PDF formats. Some additional operations have been supplemented, such as links to some important keywords (from Index), chapters or pictures. This makes those electronic manuscripts to be prepared also for the distance learning.

7 STABILITY CRITERION – AN EXAMPLE

In this section we demonstrate the use of the Linear Systems Theory Education Tool together with the electronic manuscripts for determing stability according to the Routh criterion.

We chose Mathematical models from the main menu chapter and then we chose the Routh criterion. We can find out from the chapter graphical menu that the examples are available for continuous and discrete systems, but only for Matlab. The other two check buttons (Matlab and Simulink) are gray and not available. The Selected button starts the program (with function Routh, not included in Matlab) in the main Matlab window, with the following result.

```
% Stability according Routh criterion (VhodIzhodRouth)
% About Routh criterion ...
% See also: ROUTH, VHODIZHODROUTHD
% Continuous system with characteristic equation:
KE = [1 4 5 2];
CharactEqn = poly2sym(KE,'x')
CharactEqn =
x^3+4*x^2+5*x+2
%  Function Routh gives the following result:
R = Routh(KE)
Routh =
  [   1,   5]
  [   4,   2]
  [ 9/2,   0]
  [   2,   0]
System is stable!
Polynom =
   x^3+4*x^2+5*x+2
RouthTable =
  1.0000    5.0000
  4.0000    2.0000
  4.5000         0
  2.0000         0
```

Izbrani primer prikazuje sintakso funkcije Routh in njeno uporabo za izbrani primer. Pomoč je organizirana na način, kot je to običajno v Matlabu. Uporabimo jo lahko v Matlabovem delovnem oknu ali pa s pritiskom na gumb Pomoč v enem izmed izborov. Dokumentacijo v PPJ HTML je mogoče priklicati iz Matlabovega okna 'Pomoč' ali pa podobno kakor prej s pritiskom na gumb 'pomoč HTML'.

Vsako poglavje ima svoj lasten opis, ki je grafično bolj obsežen in za katerega smo uporabili Matlabov prikaz (sl. 6).

Primer kratko prikazuje principe grafičnega uporabniškega vmesnika in njegovo uporabo. Vključili smo mnogo drugih primerov in pri tem skušali uporabiti čimveč različnih metod. Vgradili smo na primer tudi grafično orodje RLTOOL, v katerem smo spremenili le pomoč v slovenščino.

8 PRIMERJAVA DVEH RAZLIČNIH RAČUNALNIŠKO PODPRTIH METOD UČENJA

Končno smo povabili študente k izpolnjevanju vprašalnika o dveh različnih računalniško podprtih učnih metodah:

- računalniške vaje z video predstavitev ob stalni pomoči učitelja,
- individualno reševanje problemov z uporabo predstavljenega orodja in učbenikov.

Zajeli smo dve različni populaciji: v prvi skupini so bili študentje, ki so se praviloma prvikrat srečali z Matlabom, v drugi skupini pa študentje, ki so se z orodjem že srečali. Postavili smo jim podobna – primerljiva vprašanja in odgovori so bili presenetljivo podobni. Bistvene ugotovitve je mogoče videti v analizi odgovorov (sl. 7).

Iz odgovorov je mogoče zbrati najpomembnejše sklepe: s predlaganim orodjem prispevamo k preglednosti, povečamo količino informacij, povečamo stopnjo samostojnega dela in prispevamo z znanjem k drugim predmetom.

This example shows the syntax of the Routh function and how it is used for a specific problem. Help is organized in the same way, as is usual in Matlab. We can use it from the Matlab main window or it starts after clicking on the "Help" button in chapter or main menu. The HTML documentation can be browsed from the Matlab help window (relative to the chosen example) or with a click on the 'HTML Help' button.

Each chapter also has its own description, which is graphically more comprehensive and is based on Matlab Show (Figure 6).

This example briefly presents the principles of this GUI and its usefulness. Many other interesting examples using different techniques provided in Matlab are also included. For example, a graphic tool RLTOOL is incorporated, in which the ToolTips are rewritten in Slovene.

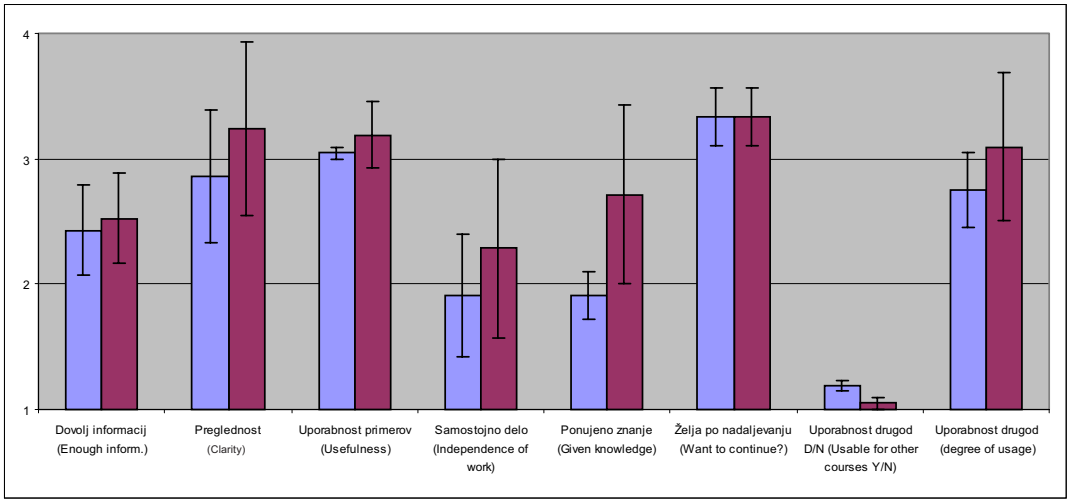
8 COMPARISON OF DIFFERENT COMPUTER-ASSISTED LEARNING METHODS

Finally, we invited students to answer questions about two different computer-assisted learning methods:

- video presentation with exercises in a computer room and the assistance of a teacher,
- individual problem-solving using the presented tool and manuscripts.

We invited two different groups to the comparison: the first group consisted of first-time users of Matlab and the second one of advanced users. Both groups received comparable questions and the results of the comparison were very similar. Some of the results are in Figure 7.

From the answers it is possible to conclude that this tool contributes to the clarity of the presented information and to the quantity of information, enlarges the amount of independent work and contributes knowledge to other courses.



Sl. 7. *Analiza odgovorov*
Fig. 7. *Analysis of answers*

9 RAZPRAVA

Računalniška in programska tehnologija lahko igrata pomembno vlogo pri prikazovanju rešitev za učenje na daljavo in za vseživljenjsko učenje. Mnogi tržni paketi, ki so dostopni na tržišču za tehnične predmete, so zelo zapleteni za uporabo ali pa ne dajejo dovolj funkcij, da bi lahko z njimi izvedli želene naloge. Matlab je interaktivni programski jezik, ki pripada prvi skupini zaradi velike količine funkcij. Predstavljeno orodje je močno grafično orodje, s katerim lahko izvajamo izobraževanje in je odprto za različne razširitve. Daje močno pomoč z uporabo mnogih orodij in funkcij znotraj Matlaba. Izdelano je bilo z namenom, da bi dali pomoč v maternem jeziku. Kljub vsemu povedanemu učenje iz rešenih problemov lahko uporabljamo le kot dodatno pomoč, ki ne more nadomestiti klasičnega izobraževanja.

9 DISCUSSION

Computer and software technology can play a significant role in solutions for distance and life-long learning. Many of the commercial packages available on the market for engineering courses are either very complex to use or do not provide all the necessary functions to achieve particular tasks. Matlab is an interactive programming language that belongs to the first group because of its large number of functions. The presented Linear Systems Theory Education Tool is a powerful graphical tool for carrying out engineering education and is suitable for improvements. It provides a lot of support using many of the available tools and functions in Matlab. This tool is designed to provide support in the students' native language. However, learning from solved problems is only intended to augment, not replace, classical education.

10 LITERATURA
10 REFERENCES

[1] Anand, P.G., A. Zaimi (2000) Computer-managed instruction: evaluation of alternative methods of technology integration in higher education, *Educat. Tech. & Soc*., 3 (1).

[2] Buckman, A.B. (1999) VI-based introductory electrical engineering laboratory course, *Int. J. Engng. Ed.*, 15 (5).

[3] Ertugrul, N. (1999) Towards virtual laboratories: a survey of LabVIEW-based teaching/learning tools and future trends, *Int. J. Engng. Ed*., 15 (5).

[4] Brooking, C.J., D.A. Smith (1999) Simulation and animation of kinematic and dynamic machinery systems with Matlab, *Comp. in Educ.* J., 9 (2), 2-3.

[5] Ghassemlooy, Z., R. Saatchi (1999) Software simulation techniques for teaching communication systems, 36 (4), 287-97.

[6] Chetty, M., Y.K. Tang (1999) A simple interface for running Matlab programs via Web, *Comp. in Educ. J.,* 9 (4), 29-33.

[7] Bradber, R. (1999) The effectivness of teaching introductory electronics in an integrated teaching studio environment, *Int. J. Engng. Ed.*, 15 (5), 344-52.

[8] Schmid, C. (1999) A remote laboratory using virtual reality on the Web, *Simulation*, 73 (1), 13-21.

[9] Adobe Acrobat 3.0, online guide, 1996.

[10] Matlab, User manuals, *Mathworks*, 1998.

Naslov avtorjev: dr. Martina Leš
prof.dr. Boris Aberšek
Univerza v Mariboru
Pedagoška fakulteta
Koroška cesta 160
2000 Maribor
les@uni-mb.si

Authors' Address: Dr. Martina Leš
Prof.Dr. Boris Aberšek
University of Maribor
Faculty of Education
Koroška cesta 160
2000 Maribor, Slovenia
les@uni-mb.si

Prejeto: 7.11.2001
Received:

Sprejeto: 20.9.2002
Accepted: