
The University of Algarve Informatics Laboratory

UALG-ILAB
Technical Report No. 200701
January, 2007

A Virtual Logo Keyboard for People with Motor Disabilities

Stéphane Norte, and Fernando G. Lobo

Department of Electronics and Informatics Engineering
Faculty of Science and Technology
University of Algarve
Campus de Gambelas
8000-117 Faro, Portugal
URL: `\protect\vrulewidth0pt`<http://www.ilab.ualg.pt>
Phone: (+351) 289-800900
Fax: (+351) +351 289 800 002

A Virtual Logo Keyboard for People with Motor Disabilities

Stéphane Norte

UAlg Informatics Lab
DEEI-FCT, University of Algarve
Campus de Gambelas
8000-117 Faro, Portugal
snorte@ualg.pt

Fernando G. Lobo

UAlg Informatics Lab
DEEI-FCT, University of Algarve
Campus de Gambelas
8000-117 Faro, Portugal
fobo@ualg.pt

Abstract

In our society, people with motor impairments are oftentimes socially excluded from their environment. This is unfortunate because every human being should have the possibility to obtain the necessary conditions to live a normal life. Although there is technology to assist people with motor impairments, few systems are targeted for programming environments. We have created a system, called Logo Keyboard, to assist people with motor disabilities to program with the Logo programming language. With this special keyboard we can help more people to get involved into computer programming and to develop projects in different areas.

1 Introduction

Computer programming is an important activity occupying a large number of students in our society. Disabled people have reduced opportunities in a lot of areas, and the field of education is no exception. A virtual environment offers the possibility to control or operate in the real world partly alleviating physical limitations. Most people use their arms, hands, and fingers when using a computer, namely a keyboard and/or mouse. Nevertheless, for people with motor disabilities, the need for controlled movements can be an obstacle for them to be able to interact with the computer. There are many types of physical disabilities that affect a pleasant human-computer interaction. Several diseases cause muscle deterioration and/or neurological disorders that can result in physical weakness, loss of muscle control, paralysis, and amputation. The main problem for people with physical disabilities is the capacity to access computer controls (i.e. power switch, disk drives, monitor adjustments) and the ability to type on the standard keyboard or move pointing devices like a mouse.

People with motor impairments can use alternative keyboards which replace the standard keyboard for input of information into the computer. In this paper, we present the virtual Logo Keyboard. With this tool we provide an easy way to help people program in Logo. Our work focuses on Logo because it is an excellent programming environment. The Logo Programming language was designed as a tool for learning. It is not only extensible, but flexible and interactive. For most people, learning Logo is not an end in itself, but a beginning. The Logo programming language is useful to create activities in science, language, music, robotics, telecommunications and mathematics [12]. MicroWorlds, StarLogo, UCBLLogo, and MSWLogo, are examples of some of the most popular Logo interpreters.

One of the most significant motivations for including Logo in the beginning of educational computing is that Logo presents an example of a way in which computers can be used to reconceptualize the teaching and learning process, rather than simply to improve or enhance traditional forms of learning. From the beginning, Logo was created to be a mathematical learning environment, as well as a programming language [5]. Seymour Papert, Logo's principal creator, based his inventions on his years of work with Jean Piaget, the Swiss philosopher and psychologist who has done so much to promote understanding of the ways in which children construct their own learning in natural settings [11]. Using Logo as a programming language is also an excellent introduction into the world of computer science and programming. Programming is a key intellectual activity associated with both the many uses of computers in the real world, and the educational uses of computers in elementary and middle schools and beyond.

In the next section, we present some background related to this work. Then, section 3 presents the development of the virtual Logo Keyboard and its motivation. Section 4 describes usability tests conducted with 3 children. Finally, we describe an outline of future work in section 5, and the conclusions in section 6.

2 Background

There is a large amount of work in assistive technology and in building computers more accessible to people with disabilities and learning difficulties [14, 2, 4]. However, there is less work focused on assistive technology to help people to program in an educational environment. This section describes previous research on virtual keyboard technology specifically designed to provide people with motor impairments the ability to interact with a computer.

2.1 Virtual keyboard technology

Virtual tools can facilitate the manipulation of computer devices [16]. Most virtual keyboards are based on the physical layout of a standard keyboard [8]. Before the user can select anything on the screen, she need physical instruments for a direct interaction [6]. Many devices are used to obtain this access. For example, switches, pointing devices, joysticks, physical keyboards, mice, trackballs, and webcams. Some people may have difficulties in using a standard keyboard. The Logo Keyboard uses a scanning system to help people interact with the computer. The scanning method is widely used among the disabled in various computer-aided systems. Scanning techniques allow the user to use one switch to change the focus from one item to another. The focus automatically shifts from item to item after a predefined time has elapsed and all the user has to do is to press a single switch or key when the desired item is in focus [13, 7].

3 Development of the Virtual Logo Keyboard

The Logo Keyboard was developed with the purpose of aiding and integrating people with motor impairments in a programming environment. Some studies reveal that people with certain limitations, motor or cognitive, can develop programs [15]. Unfortunately, many children and adolescents remain frustrated in schools due to a lack of assistive devices. Through this interface we make it possible for users, or carriers of impairments to use the Logo language. The Logo Keyboard can be used with a Logo interpreter, for example, MicroWorlds Pro, UCBLLogo, or MSWLogo. The interaction of the user with the virtual Logo Keyboard begins with a touch on an assistive device (mouse,



Figure 1: Logo Keyboard Interface - Vocabulary Menu.

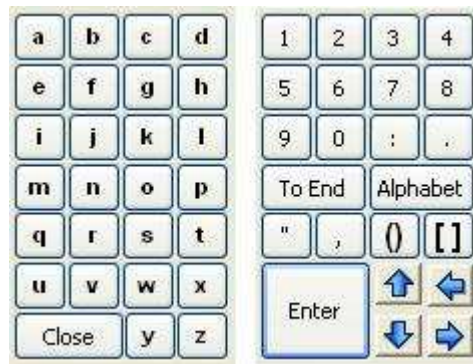


Figure 2: Alphabetic and numeric keyboard.

switch, or keyboard). The message is sent to the Logo Keyboard and the chosen Logo command is sent to the command window (output stream) where it is executed by the Logo interpreter.

3.1 Logo Keyboard Interface

The Logo Keyboard interface was created in C++. It contains an adjusted environment to support different kinds of aids. The keyboard was created with special keys to produce an output of Logo programming commands. Each vocabulary was put into separate groups allowing the creation of an organized form of a keyboard with 312 keys (Figure 1).

In addition to the Logo programming commands, there's the possibility of using a numeric or alphabetic keyboard (see Figure 2).

The Logo Keyboard has a system that allows the user to modify the interface transparency depending on the needs of the users. The options menu have useful features. It includes an integrated help system providing information about each command along with a brief description and an animated example of its use (see Figure 3).

The zoom options help people with visual impairments to zoom any given key. This feature is extremely useful for people with low vision. It can be used with the assistance of the mouse, placing it in the intended key or automatically through the scanning system (see Figure 4).

The user can configure several options of the keyboard, such as: scanning velocity, number of



Figure 3: The user places the mouse under the intended key and visualizes the help system about that key / command.

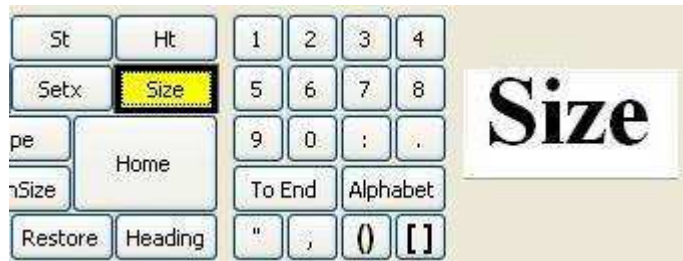


Figure 4: The scanning system allows zooming a command without the use of a mouse.

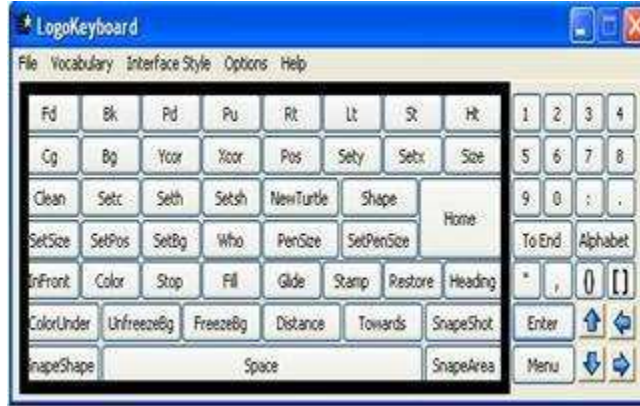


Figure 5: An example of the scanning system. There are 2 principal groups of keys (Logo commands and numeric/alphabetic), and the cursor advances through each group at a specified rate.

repeat scanning cycles, scanning sound, scanning color, and keyboard size. The user also has the possibility to identify Logo commands with a voice system when the mouse moves over them.

One of the aspects that was carefully thought about was the possibility to develop an easily accessible and configurable interface. A person with disabilities can press a single button to configure or use the interface without assistant's help (except if the option of the aid commands is turned on). Through the scanning mechanism, the keyboard can completely assist a user with motor impairment [1].

3.2 Input Methods

People who are able to use a mouse, can easily use the Logo Keyboard to build Logo programs using a simple click of the mouse under the desired key. It is important to pay attention to where the last mouse focus was. The principal target of the Logo Keyboard is to be used with a Logo interpreter, but it can also be used to write some text with the alphanumeric keyboard. People who cannot use a mouse are able to use the scanning mechanism of the keyboard. There are two important scanning groups (Figure 5): The first is used to select the programming keyboard keys; The second is used to select items in the numeric or alphabetic keyboard. After the user has selected one of the groups, the selection is recognized and the scanning proceeds under subgroups of the original group. Eventually, the scanning system focuses on single keys, one at a time (see Figure 6). In this phase the next click will be the choice of the desired key. To use the scanning system, the user needs to press the "Space" key or use a switch. The Logo Keyboard presents important features, facilitating and increasing the writing speed of issuing commands.

3.3 Motivation and Learning with Logo keyboard with disabled Children

The experience with Logo philosophy using computers with children with disabilities shows that computers can offer a new way to educate [3]. The computer can be a tool with which the child can develop abstract thought, express ideas previously inaccessible, and be an active and creative element. Logo has a lot of characteristics to help create an ideal learning environment for children with disabilities. Primarily, the materials that the child has to operate in the Logo environment are not physical objects that require a high degree of motor coordination. The objects are controlled by the computer. The Logo Keyboard is an instrument that helps to minimize the barriers between the

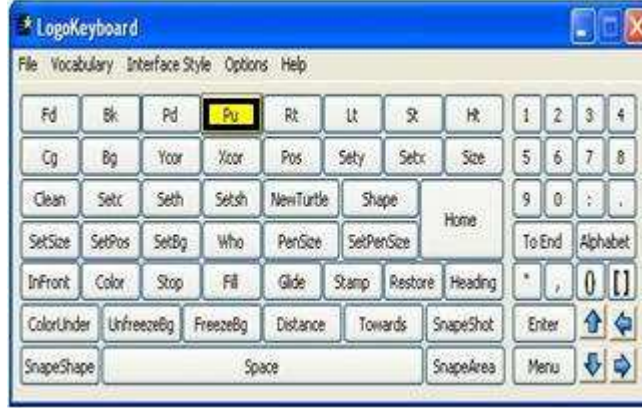


Figure 6: In this example, the first row of the first group was selected, and now, the scanning system becomes focused on the keys of that subgroup, with the cursor advancing through each of the Logo commands one at a time.

child and the physical world. Thus, if the child has enough motor coordination to control a single touch button, she can control the Logo Keyboard and do everything that they want without needing aid of other people. The activities that the child develops in a Logo programming environment can be determined by their own interest and imagination. This is very important because it allows the keyboard to transform the passivity of the child with disabilities. The Logo exercise allows the formation of the intuitive knowledge of the child and it allows others to see the process that it uses to develop a specific activity. The perspective of education in accordance with the Logo philosophy consists of giving children the power to reach their potential and to forget about their disabilities. As advocated by Seymour Papert, children should be provided with a proper environment for being constructors of their own knowledge, learning along the way with their own mistakes. The technology will help us to provide more opportunity for teachers to work with students on projects where they will mutually implement their ideas [9, 10].

4 Usability tests

We have made usability tests of the Logo Keyboard with students of a highschool. The students learned the introduction to Logo programming with a regular keyboard, but we soon realized than some of them revealed physical motor impairments to control a regular keyboard. To help these children we used the Logo Keyboard and we created some experiments. The population of the study consisted of three students between the ages of 15 and 17. The students who have been investigated have different characteristics. One of them does not have any motor impairment although the others do have. Each student was assigned to write the same program (shown in Figure 7), using different techniques to make it. The users with disabilities used the Logo Keyboard and the others wrote the program with a regular keyboard. Table 1 summarizes the total number of key-presses made and the time taken.

Daniel

Daniel is a 15 year old boy without motor impairments. To create projects in Logo he uses a physical keyboard at school. When given the opportunity to learn the Logo Keyboard in the classroom,

```

to square
  make "n 4
  repeat (:n) [fd 30 rt 90]
end

```

Figure 7: Program used in the experiment.

Table 1: Summary of the typing tests.

Student	Device	No. of Key-presses	Time (secs)
Daniel	Physical Keyb.	56	46
Ana	Virtual Keyb.	108	404
Nilton	Virtual Keyb.	27	73

Daniel used one of the existing options of the keyboard. The feature used was the help system about the Logo commands. He said: “This feature is excellent to learn the Logo language and how to use it”. Daniel confirmed that with this tool, any pupil could learn by himself how to program in Logo. His evolution was fantastic; he constructed his own knowledge with his own mistakes.

Ana

Ana is a 16 year old girl with motor impairments. She needs the aid of a wheelchair to be able to move. Her interaction with computers is good but she does not like to use a conventional mouse. Ana prefers using a trackball because it is less tiring for her. To program in Logo, she prefers using the Logo Keyboard scanning system. In spite of a slightly longer delay, she liked the experiment. Ana was able to reach each goal and she admitted that at home she wanted to use a trackball to continue developing Logo projects with the help of the Logo Keyboard.

Nilton

Nilton is a 17 year old boy, with poorly developed fingers. Each hand has three fingers of extreme size. This disability stops him from exercising diverse tasks at school. In the classroom, Nilton learned how to program in Logo, but we quickly understood that he was frustrated due to the fact that he could not keep up with his colleagues. Nilton used the Logo Keyboard to continue his work. Using a mouse to control the interface, Nilton was able to program very quickly and to exceed some of his colleagues. Throughout the school year, Nilton’s confidence grew and he exceeded his limitations showing that he was a good programmer. A direct quote from him follows: “With the Logo Keyboard I had the possibility to enjoy the same rights as my colleagues - Learn Logo”.

Results

At the end of the experiment, a small questionnaire was given to the students to understand the degree of satisfaction concerning speed, usability and precision of the Logo Keyboard (table 2):

Table 2: Subjective ratings of speed, efficacy and precision when using the Logo Keyboard and a physical keyboard. Ratings were provided on a scale from 1 (weak) to 5 (good).(P-Physical V-Virtual)

Student / Keyboard	Speed		Usability		Precision	
	P	V	P	V	P	V
Daniel	5	4	4	4	4	5
Ana	1	2	2	5	2	4
Nilton	2	5	2	5	3	4

Discussion

It was verified that the Logo Keyboard was able to assist the students positively by increasing their performance, speed and accessibility to program. From the tests we can observe that an individual that can manipulate a mouse to use the Logo Keyboard is able to program more easily than an individual that uses a conventional keyboard.

It is verified that the use of the scanning system can generate a longer delay to select a desired Logo command, but the amount of characters does not become a negative aspect, due to the fact that a complete Logo command can be selected at once, rather than typing the individual characters that constitute the command. This can potentially improve their overall typing rate. The users who do not have motor impairments do not have great advantages in the use of the Logo Keyboard other than using the integrated help system. The main goal of the sample program used in this study was to test the biggest difficulties felt by the students with disabilities—the simultaneous manipulation of two keys which, on a regular keyboard, are required to produce special symbols that often appear in computer programs (for example, [,], :, (,), ' '). The Logo Keyboard attenuates this problem and is, without doubts, one of the advantages that the students most appreciated.

5 Future work

There is a great interest in the creation of educational interfaces mainly with the Logo programming language. In the near future, we intend to improve the Logo Keyboard with new options, new configuration and new scanning systems. We would like to continue to test the Logo Keyboard with more individuals with motor impairments including people with cerebral palsy. We also intend to create interfaces that can help people with severe motor impairments to control the movement of a mouse quickly and easily in different Logo environments. Our current goal is primarily focused on expanding the use of computer programming among people with disabilities. We intend to work

6 Conclusions

This paper presented the Logo Keyboard, a system to be used by individuals with physical disabilities to program in Logo. The Logo Keyboard discussed in this paper is available for free use and can be downloaded from <http://w3.ualg.pt/~snorte/LogoKeyboard>. We hope that the Logo Keyboard will be useful to many people, and that we can continue to explore new ways to aid people with disabilities. The observations and the studies with children were very beneficial to un-

derstand the needs and problems in the Logo learning environment. We expect that Logo or other programming languages may provide a good window for children to discover learning pedagogy and problem solving methods. Our work should also encourage researchers to explore new ways in which other programming languages and essential techniques can be used by users with disabilities.

Acknowledgments

We sincerely thank the children and student testers in the school. This work was sponsored by the Portuguese Foundation for Science and Technology (FCT/MCES) under grant POCI/CED/62497/2004.

References

- [1] P. A. Condado, P. F. Miquelina, S. Norte, N. Castilho, F. G. Lobo, and H. R. Shahbazkia. Information and communication technologies for people with disabilities. In *Interactive Computer Aided Learning International Conference*. Carinthia Technology Institute, Villach, Austria, 2004.
- [2] Patrick W. Demasco and Kathleen F. McCoy. Generating text from compressed input: an intelligent interface for people with severe motor impairments. *Commun. ACM*, 35(5):68–78, 1992.
- [3] E. P. Goldenberg. *Special Technology for Special Children*. University Park Press, Baltimore, 1979.
- [4] S. W. Hawking. *Computer Resources for People With Disabilities: A Guide to Assistive Technologies, Tools, and Resources for People of All Ages*. Hunter House Publishers; 4th edition, 2004.
- [5] Celia Hoyles and Richard Noss, editors. *Learning mathematics and logo*. MIT Press, Cambridge, MA, USA, 1992.
- [6] Simeon Keates, Faustina Hwang, Patrick Langdon, P. John Clarkson, and Peter Robinson. Cursor measures for motion-impaired computer users. In *ASSETS*, pages 135–142, 2002.
- [7] P. Majaranta and Kari Jouko Räihä. Twenty years of eye typing: systems and design issues. In *ETRA '02: Proceedings of the 2002 symposium on Eye tracking research applications*, pages 15–22, New York, NY, USA, 2002. ACM Press.
- [8] B. Myers, J. Wobbrock, S. Yang, B. Yeung, J. Nichols, and R. Miller. Using handhelds to help people with motor impairments. In *Proceedings of the Fifth ACM Conference on Assistive Technologies*, pages 89–96, Edinburgh, Scotland, 2002. ACM Press.
- [9] S. Papert. *Mindstorms: Children, computers, and powerful ideas*. Basic Books, New York, 2nd edition, 1993.
- [10] S. Papert. *The connected family: Bridging the digital generation gap*. Longstreet Press, Inc., 1996.
- [11] J. Piaget. Problems of the social psychology of childhood. In *Sociological studies*, New York, 1960.

- [12] Mitchel Resnick. *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds*. The MIT Press, 1997.
- [13] C. E. Steriadis and P. Constantinou. Designing human-computer interfaces for quadriplegic people. In Annie Wu, editor, *Proceedings of the ACM Transactions on Computer-Human Interaction (TOCHI)*, pages 197–200, New York, 2003.
- [14] Shari Trewin. Automating accessibility: the dynamic keyboard. In *Assets '04: Proceedings of the 6th international ACM SIGACCESS conference on Computers and accessibility*, pages 71–78, New York, USA, 2004. ACM Press.
- [15] Jose A. Valente. *Creating a Computer-Based Learning Environment For Physically Handicapped Children*. PhD thesis, Massachusetts Institute Of Technology, September 1983.
- [16] Shumin Zhai, Michael Hunter, and Barton A. Smith. The metropolis keyboard - an exploration of quantitative techniques for virtual keyboard design. In *UIST '00: Proceedings of the 13th annual ACM symposium on User interface software and technology*, pages 119–128, New York, USA, 2000. ACM Press.