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The Transformation of Web-Based e-Learning Lessons for Visually-Impaired Persons Based on State Machine Sequence Control

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Abstract

In this paper, we describe a technique based on finite state machine that can transform any e-learning lesson with embedded engaging elements and standard navigation control, and reconstitute this conventional e-learning lesson into an e-lesson that can be used by a visually- impaired person by means of voice-only navigation and control.

1. Introduction

Currently, there are a large number of e-learning lessons developed based on the SCORM standards [1]. The lessons can run on any SCORM compliance Learning Management System (LMS). Some of which are popular open source LMS such as Moodle [1], A-tutor [2], and many other commercial LMS such as Blackboard[3], Edugether[4], etc.

In the area of producing content for disability, the WCAG 2.0 [5] provides the guideline for designing web pages for this group of persons with different impairments. In particular, the visually impaired persons would have to rely on voice navigation including screen reader and tactile equipments to perceive and understand the content displayed on the screen. There are many researches [6-12] addressing various aspects of assistive technology and approaches to assist handicapped persons to navigate and understand web-based content. For the issue of automatic transformation of existing content into content for visually impaired persons has not been addressed since most of the content that appears on screen can be vocalized by screen reader. However, the category of e-learning content with hot spots, hyperlinks and complex navigation can not be handled by screen reader. This paper proposes a technique for transforming existing e-learning content into a content that can be used by visually impaired person.

2. General Characteristics of e-Learning Navigation

In general, there are two kinds of navigations in an e-learning package. The first type is the page navigation as shown in Figure 1 by the symbols "<" and ">" representing backward and forward navigation. This type of navigation provides a linear sequencing to the previous page or the next page. The second type of control is embedded in the contents of some of the pages to provide engaging elements of learning interaction. This type of navigation controls consists of hyperlinks, buttons, and hot spots. Shown in Figure 1 is an example of embedded navigation controls for providing engaging contents. In this case it consists of 4 buttons, C1, C2, C3 and C4. In order to learn the content of this page properly, the normal user would have to click or activate each of the buttons to see the content linked to that particular activated buttons. Normally, there is no particular order needed to sequence through all these buttons.

For a visually impaired person to use this e-learning lesson, equipped with only a conventional pointing device such as a mouse it is almost impossible for him or her to locate the proper hyperlinks, hot spots or buttons. Moreover, since there is no visual clue built-in or voice annotation about the links, hot spots or buttons. Even he or she can click on the control, he will not able to complete the lessons in due time.

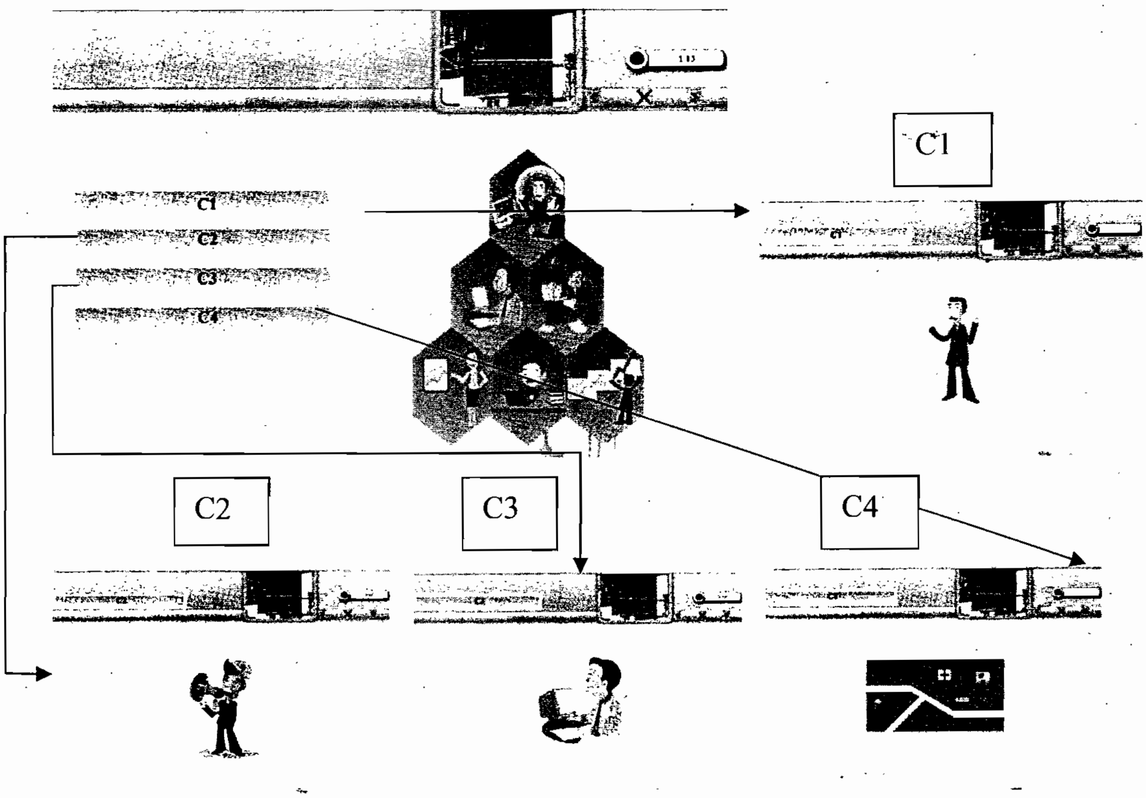

Figure 1: E-learning screen with 4 engaging elements implemented by 4 buttons

3. The Transformation Algorithm

Let us illustrate the concepts by examining a simple e-learning screen with 4 engaging elements implemented by 4 buttons as shown in Figure 1. First, - the algorithm will have to identify the 4 buttons associated with this screen and then a 4 nodes state state machine is generated depicted in Figure 2. The 4 buttons will activate 4 sub-windows explaining the four associated concepts. When in this page, the visually impaired user will listen to the navigation voice guiding through each control state of the state machine. Suppose that the user choose to activate the button when in state C2, then after the presentation of the concept, the control will return to the state machine, taking the next node as a primary node in the sequence. And the state machine basically is reducing to have only 3 states forcing the user to choose one of the remaining controls. However, it is also possible not to reduce the original states but this would lengthen the navigation processes and might hinder the normal learning process of the user. In the actual implementation, it can be designed to allow user to specify whether he or she wants to have full sequencing or reduced sequencing of control states. Figures 3-6 complete the picture of state reduction in learning the four engaging elements.

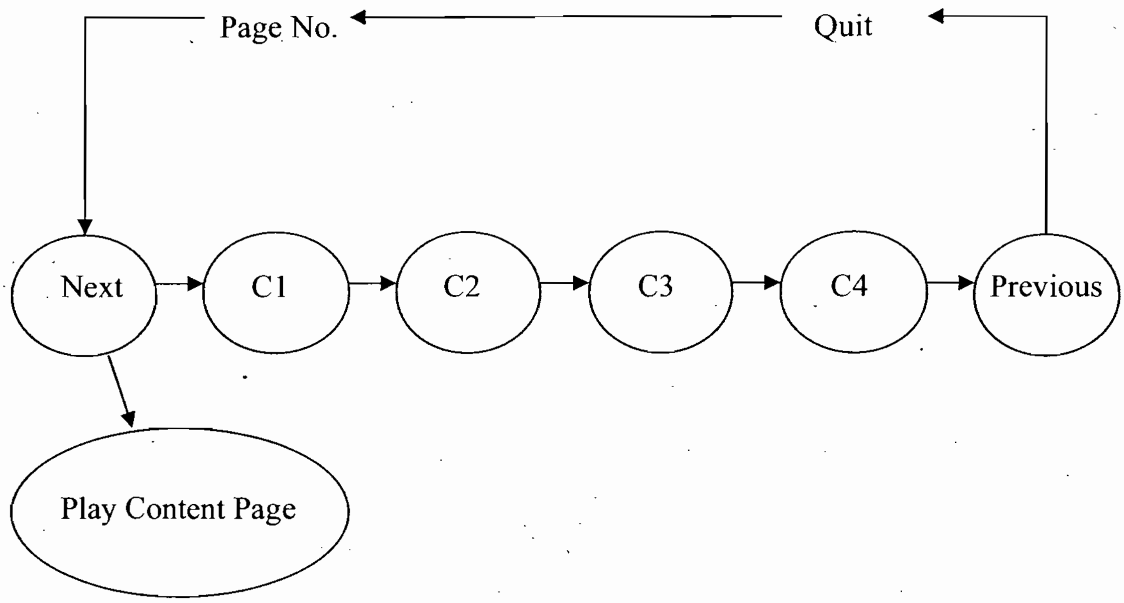

Figure 2. A finite state machine representing the sequencing of engaging elements for the e-learning page shown in Figure 1.

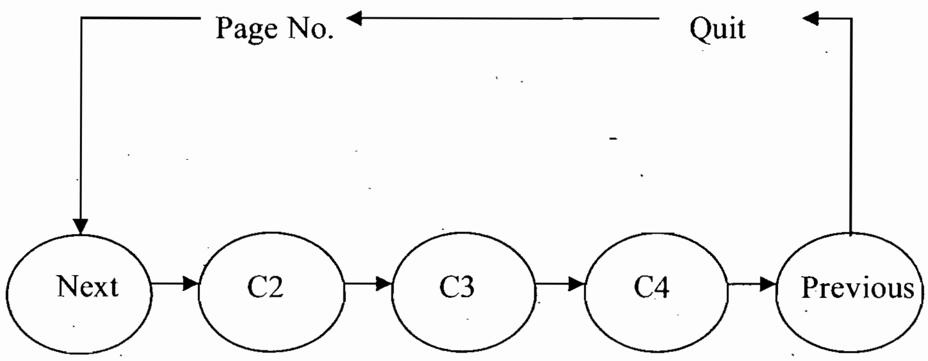

Figure 3. The finite state machine after activating the engaging element C1.

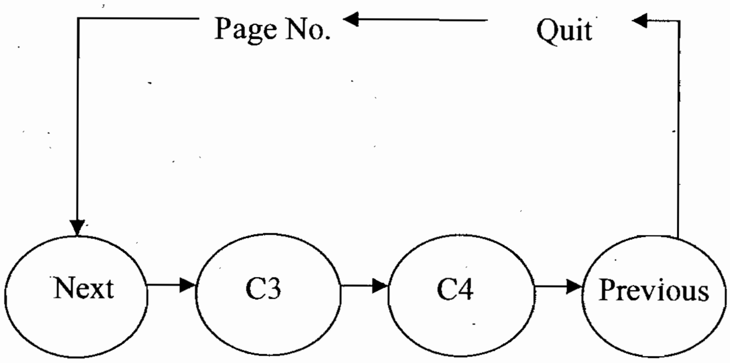

Figure 4. The finite state machine after activating the engaging element C2.

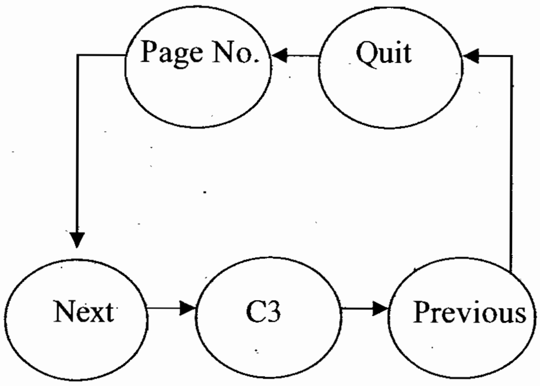

Figure 5. The finite state machine after activating the engaging element C4.

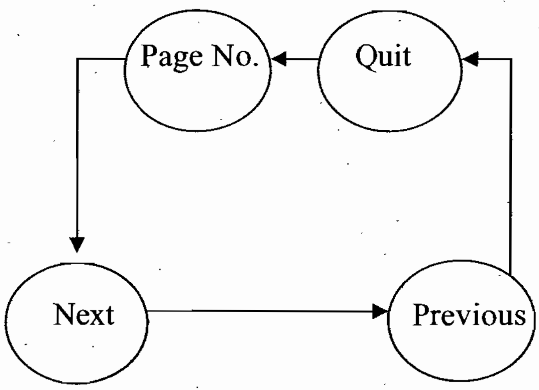

Figure 6. The finite state machine after activating the engaging element C3.

Let S = {Cnext C1, C2, C3,…, Cn, Cprevious, CQuit, CPageNo} be the set of engaging elements in a page. Sa = {Ci,Cj,Ck,…} be the set of engaging elements that have been engaged. Initially, Sa = {}, an empty set.

Hence, S – Sa is the set of the remaining engaging elements that waits to be activated. Let N be the number of engaging elements in page m, the transformation algorithm is given as follows.

(1) Scan the ims manifest file and associated files to detect each page's engaging elements and create the Si, for page i.
(2) Create the annotation list associated with each element in S.
(3) Create the set Sa, initially empty.
(4) Sequence the state in S-Sa until all Cquit is activated or all content states are covered, and C1, C2,…, Cn have been removed from S and put in set Sa. When executing this algorithm, if the control CQuit is activated, the learner will exit from the lesson.
(5) let Ci be the current state.
(6) Cj= next state;
(7) for engaging element Ci in S-Sa,
annotate-state Ci for all i"if want to activate Ci , click the left button now"
Wait for Ci activation, set timer.
If no activation is detected within the set timer, then move
to element cj in S-Sa, move to the next state, repeat (6) and (7)
if activation of Ci is detected within the set timer interval, then put Ci in Sa, present the content associated with Ci ;
When finished,
ask if need to be repeated
If yes, then proceed to repeat and goto state Ci
If no, then go to state Cj

4. Implementation Note

The implementation of the transformation algorithm needs to have voice navigation to be inserted at the appropriate control points. Also; the javascript implementing the finite state machine has to be designed taking care of the learner's interaction with the system with only the left and right buttons.

5. Conclusion

In the area of web or content accessibility for the visually impaired person, screen reader now becomes a standard devised that assit the transformation of textual content to voice content. The category of web-based content called e-learning which has been developed in the last five years becoming widely available for educational usages and public accesses. Most of these content have voice annotation. However, there are increasing employs engaging techniques in the design of modern immersive e-learning lessons. It is impossible for the visually-impaired persons to identify the correct positions of those hyperlinks, hot spots and buttons. This paper describes a technique based on finite state machines to chain all the engaging elements and controls together in such a way that the conventional e-learning now can be reconstituted into an e-learning package that can be used by the visually-impaired person.

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