DEVELOPMENT OF VOICE-BASED MULTIMODAL USER INTERFACES

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Abstract: In the last decades, the interface evolution made the visual interfaces popular as standard and the keyboard and mouse as input device most used to the human-computer interaction. The integration of voice as an input style to visual-only interfaces could overcome many of the limitations and problems of current human-computer interaction. One of the major issues that remain is how to integrate voice input into a graphical interface application. In this paper, we introduce a development method of multimodal interfaces combining voice and visual input/output. In order to evaluate the proposed approach, a video application multimodal interface was implemented and analysed.

1 INTRODUCTION

According to Raskin (2000), the user's interface establishes the devices in which the user must interact with a computing system and the way that this system invites and answers user's interaction. This definition brings two important concepts to be analyzed: the interface devices and the styles of interaction available to the user.

The interface devices are parts of the computing system in which the user has physical, perceptive and conceptual contact. The interface involves a set of necessary software and hardware to allow and facilitate the communication and interaction processes between the user and the application (Carneiro, 2003). Interaction is a process that involves user's actions and interpretations about the answers revealed by this interface (De Souza,1999).

Interaction styles involve the ways used by the users to communicate or interact with an application (Preece *et al.*,1994; Shneiderman, 1998). Natural language, command languages, menus, WIMP (*Windows, icons, menus and pointers*), form filling in and direct manipulation are well-known examples of user´s interaction styles (Shneiderman, 1998). In general, as in a Graphical User Interface (GUI), different styles can be supported by an application interface.

The integration of voice as an input style to visual-only interfaces could overcome many of the limitations and problems of current user application interaction. The problems related with the voice interaction can be approached as a part of the natural language processing style type, once they involve the possibility of the computer and its applications to understand and to respond to the actions using the user's language itself (Carvalho, 1994 e Siqueira, 2001). In this case, the natural language applications are supposed to have a dictionary of words and meanings restricted to the domain, requiring the establishment of precise dialogs and restricting the possibilities of the user's pronunciation (Siqueira, 2001).

Another approach is to develop applications that support the use of natural language with few restrictions. In this case, the problems in natural language processing, as vague and ambiguous constructions with grammar mistakes need to be solved. Finally, regardless of voice interaction is treated, the speech must be considered as a possible interaction style between the user and the computer, that allows him to accomplish his tasks with more efficiency and less effort.

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Due to the overwhelming number of inputs and outputs objects in direct manipulation interfaces, users have simply many things to see or to do. Voice inputs and outputs are a natural channel, available and systematically under-utilized to improve the communication between the user and the computer. For these users, such interfaces added to the current visual ones increase the feeling of direct manipulation and enhance user's understanding (Mountford, 1990).

We consider "mode or modality" as an input and output mechanism with the user's interface (Nunes and Akabane, 2004). Thus, multimodality is defined as the combination of two or more input modalities (such as speech, touch, gestures, head movements and mouse) in a coordinate way with different available outputs in a multimedia system (Ovviat, 2002). Different from the multi-channel access which makes possible to access data and applications from different channels (such as laptops, PDAs or cellular phones), multimodal access allows the combination of multiple ways in the same interaction or section (Srivasta, 2002).

According to Maybury (2001), machines supporting multimodal inputs and generating coordinated multimedia output can bring benefits, including: more efficient interaction (less effort for the task execution), more effective interaction (tasks and dialogs regarded to the user's context) and more natural interaction (support to the combination of speaking, writing and gestures as in the man-man communication).

Within this context, this paper aims to present a process for the development of multimodal user interfaces with emphasis in the voice modality. The focus here is to present an approach towards integration of voice commands into traditional mouse based interfaces.

This article is organized as follows: Section 2 reviews paradigms of graphical interfaces interaction. Section 3 discusses voice features as an input modality. Section 4 gives the reader details of the voice interaction of the GUI and presents the GRMMI environment. Section 5 introduces the application of the proposed approach to the development of a video manipulation interface. The last section analyses the results and presents conclusions.

2 INTERACTION PARADIGMS

The term paradigm is generally used to mean a model of how something operates. An interaction paradigm specifies a model of how an interface operates (reacts) when the user executes an action on it. It also indicates the order that elements are are selected or activated by the user when he executes a task. These paradigms can be grouped in two basic styles (De Souza, 1999):

a) action + object interactions – the user selects the action to be done, and then the object on which it must interact.

b) object + action interactions – the user first selects the object and then the operation that wishes to do over it.

In a direct manipulation interface, the user hopes the system to offer representations of objects those interact like real objects themselves. These objects must have associated tasks with meanings like those of the real world. Because of this it is common to imagine that the user's interface use the interaction "object + action" paradigm. However, as depicted in Figure 1, even in well-known interface standards this paradigm is not always kept. In the first level of the interface menu structure there are elements that give us the idea of object manipulation, as File and Tools, as well as the elements which are related to the actions as Edit, View and Help. Thus, one can say that menus apply a paradigm modeled sometimes by the "action + object", sometimes by the "object + action".

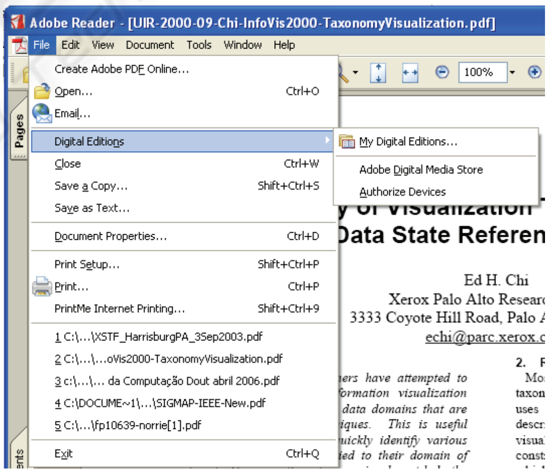
Adobe Reader - [UIR-2000-09-Chi-InfoVis2000-TaxonomyVisualization.pdf]
File Edit View Document Tools Window Help
Create Adobe PDF Online...
Open... Ctrl+O
Email...
Digital Editions
My Digital Editions...
Adobe Digital Media Store
Authorize Devices
Close Ctrl+W
Save a Copy... Shift+Ctrl+S
Save as Text...
Document Properties... Ctrl+D
Print Setup... Shift+Ctrl+P
Print... Ctrl+P
PrintMe Internet Printing... Shift+Ctrl+9
1 C:\...\XSTF_HarrisburgPA_3Sep2003.pdf
2 C:\...\...oVis2000-TaxonomyVisualization.pdf
3 c:\...\... da Computação Dout abril 2006.pdf
4 C:\DOCUME~1\...\SIGMAP-IEEE-New.pdf
5 C:\...\fp10639-norrie[1].pdf
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Figure 1: Adobe Reader main screen: an example of menu interaction.

Another important point is that, it doesn't matter what interaction paradigm is adopted, the user usually wait for a reaction of the system through the graphical interface. In the example of Figure 1, after some interactions, the different levels of the menu are detached and presented.

From the previous observations, one can say that some important problems must be solved to allow the integration of the voice commands to the GUI:

1. How to model the multimodality integration in a graphical environment that applies different interaction paradigms?
2. Which interface objects to which the natural interaction must be done with the voice?
3. How do the graphical interfaces must react to the user's voice commands even when different interaction paradigms are used?

3 THE VOICE AS AN INPUT MODALITY

Each interaction modality has its own characteristic that many times determinate its utilization. In general, the tasks made by the users on the interface are associated to the following actions (Damper, 1993):

- Selection: choose the items as in a menu.
- String: composition of a text characters sequence.
- Quantification: numeric value specification as in the case of the number of a text edition line.
- Orientation: angular quantification, as in the case of a line segment orientation.
- Position: point specification in a bi-dimensional space.
- Path: position and orientation sequence resulting in a curve in the application space.

For each action there are more or less indicated modalities. The speaking recognition (identification of the spoken words and transcription to the written text) is generally indicated to selecting and text composition tasks (string) for it proportions a more natural interaction between the user and the application. On one hand, the selection of an action through simple voice commands instead of a considerable number of keys or clicks reduce the time interaction between the user and the system. On other hand, the quantification, positioning and orientation actions become complicated, imprecise and more vulnerable to mistakes if the voice modality is used as input. Thus, these actions are more appropriated to the use of devices such as keyboard and mouse (Damper, 1993).

The input modality choice must consider some circumstances and conditions to the application use (Sun Microsystems, 1998: Hix, 1993). One can say the voice input modality is indicated in the cases where:

- The person who uses the application has the hands or eyes occupied.
- Mobility is required.
- It is not possible to use the keyboard.
- Objects or actions within a great amount of options or through a repetitive way must be selected.
- The required commands are built in within a great menu structure.
- The users have some physical deficiency, especially visual problems.

Voice-based and direct manipulation interfaces have complementary characteristics. This fact collaborates and justify the use of many modalities in a same interface (Grasso, 1996). Table 1 describes these features.

Table 1: Complementary characteristics of the voice and direct manipulation.

Direct Manipulation	Voice Recognition
Direct use	Operations without the use of hands and/ or eyes
Simple and intuitive actions	Possibility of complexes actions
Consistent appearance and behavior	Reference independent of the location
No ambiguity in the reference	Multiple ways of relating to entities

In IBM (2003) some considerations related to the voice use associated to the graphical interface are also presented. Some visual elements that need the user's input or action can be activated with the voice. Buttons, text fields, links, list box and checkbox are typical examples of this possibility, while, graphics, tables and diagrams are better presented and manipulated via graphic interface.

4 THE PROCESS OF INCLUDING VOICE IN GRAPHICAL INTERFACES

Starting from a naïve approach, the voice integration to a graphical interface could be solved with the simple association of voice commands to the objects that compose such interface. However, that this is not the most adequate way to deal with the problem.

Some tasks (e.g. a region or image marking) or situations (e.g. noisy places) voice make difficult to use as interface input modality.

It must be also observed that the use of some input modalities integrated in a complementary or simultaneous manner should be an imposed to a specific task execution.

The voice integration to the graphical interface can not just follow the graphical interface interaction paradigm because they do not have a standard: sometimes the paradigm is "action + object", sometimes it is "object + action". In general, for voice commands (e.g., "*edit this Figure*"), it is more natural for the user to mention the action first and complementing it with the object afterwards.

The problem of the interface feedback to the user's input action through the voice commands also must be treated. In other words, it is necessary that the interface allows the user to verify if the command was effectively recognized and executed. Then, the implemented solution must allow a narrow link between the voice commands and the graphical interface objects that execute similar actions. These graphic objects will give the user a feedback through reactions in the graphical interface. In Figure 1, for instance, the user could start up an action directly in the lowest Menu level ("Save As") without being necessary to pronounce the command that refer to the highest level ("File"), in an "action + object" style. However, the interface reaction would show the user that the command was recognized with the same resulting visual representation of an action with the mouse according to the Menu hierarchy. Thus, different input interactions (voice, mouse and keyboard) to the same task performance (a Menu option choice) must generate identical interface responses.

The process of including voice in graphical interfaces proposed here, are beyond the simple voice rules association of the interface graphical elements. This process intends to solve the problems listed in section 2 and is based on the following steps:

1. To indentify the use case associated to the graphical interface as a whole or a part of it (i.e. a module, a component etc.);
2. For each use case identified, to define the interface actions and components that are part of it;
3. To define the grammar rules that associate voice commands to graphical components;
4. To create a file (XML) that defines the pronunciation hierarchy from defined grammar commands, if necessary;
5. To define the parameters associated to the voice commands, if necessary;
6. To identify the situations of the activation and deactivation of the grammar rules for each use case;
7. To implement a method that produce the visual feedback associated to the execution of the voice commands in the interface.

The use cases from phase 1 allows the identification of tasks to be executed with the interface and the adequate functions to the voice interaction. The action definition and the grammar associated with voice interaction can be done in a general way to any interface component and independent of the adopted interaction paradigm. The grammar rules define, consequently, the words or sentences (tokens) that should be accepted by the recognizer.

Another important point is the specification of a precedence hierarchy between the voice commands. This hierarchy avoid the user from pronouncing any voice rule defined in a grammar in any order. This approach has direct impact in the recognition system performance. Furthermore, the hierarchy relates in a clear way "*what is possible to say now*" (voice interface) at the moment and "*what is possible to do now*" (graphical interface), keeping the user informed on the result of his/her interactions through a visual interface feedback. It means that enabling (disabling) a graphical component related to it and vice-versa.

Once there is any treatment related to the complementary and simultaneous multimodal commands to the grammar rules (e.g. voice and mouse use to zoom part of a digital image), it is suggested to these commands to be identified and modeled to the following way: L (location) – A (action) – O (object) – P (parameters). The "location" is given by the mouse position in this case; "action" corresponds to the action of zooming; "object" corresponds to the image and the "parameters" to the complementary information necessary to the action (how much the image must be enlarged).

The steps 3, 4 and 5 are executed with help of a environment called GRMMI (Grammar Rules for MultiModal Interfaces). This environment supports both voice grammars and hierarchies specification and the execution of the multimodal application that applies the specified grammars. The part of environment related to the integration between what was pronounced and the interface reactions is called GRMMI engine. Hence, it is an intermediator between voice and visual interfaces modes. GRMMI engine is in charge of identifying the grammar rule associated to the token (accepted word) pronounced (uses the grammar rules), verifying if there is a foreseeing precedence hierarchy for such token (it uses the hierarchy file – XML) and then enable and unable according to this hierarchy the adequate grammar rules, as well as in maintaining the harmony with the graphical objects. This means that once enabled or disabled, the voice command, the graphical object associated to it will also be enabled or disabled, giving a visual response to the application user.

The GRMMI engine offers many available functions which can be used in applications with graphical interfaces, as long they are created to the grammar and XML files necessary to the definition of the voice interface in steps 3 to 5 of the proposed approach.

5 CASE STUDY

As an illustration of the proposed process, consider the example of the interface from one of the components of an interface for the annotation of digital videos (player component) (Santos et. al., 2004).

Two use cases are associated to this interface component, as depicted in Figure 2:

(i) “watching video”

(ii) “describing video segment”.

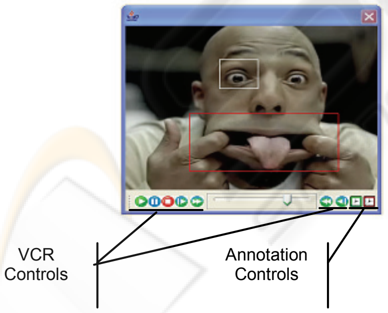
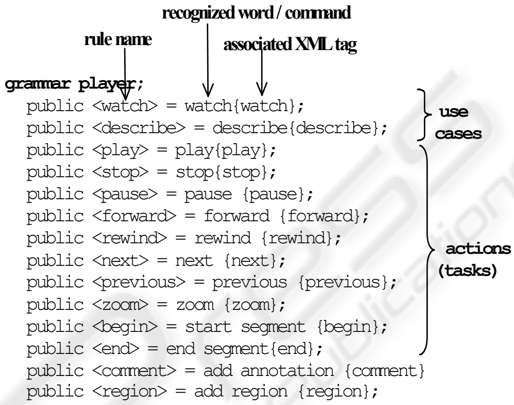


Figure 2: Player component interface.

The related actions to these use cases are described bellow: for the use case “watching video”, the associated actions are the typical controls from a VCR. The associated actions to the use case “describing video segment” allows the splitting up of the video at a time (begin and start) and the description of the created segment (add region, add annotation).

1. To watch video: play, pause, stop, next, forward, rewind and previous.
2. To describe video segment: start segment, end segment, add region, add annotation.

Figure 3 illustrates the rules grammar for the previous player component.



```
grammar player;
   public <watch> = watch{watch};
   public <describe> = describe{describe};
   public <play> = play{play};
   public <stop> = stop{stop};
   public <pause> = pause {pause};
   public <forward> = forward {forward};
   public <rewind> = rewind {rewind};
   public <next> = next {next};
   public <previous> = previous {previous};
   public <zoom> = zoom {zoom};
   public <begin> = start segment {begin};
   public <end> = end segment{end};
   public <comment> = add annotation {comment}
   public <region> = add region {region};
```

Figure 3: Player component grammar.

The following step is the creation of the commands hierarchy. This hierarchy allows the establishment of which interface components (commands) must be enabled (disabled) when the user performs a voice commands sequence.

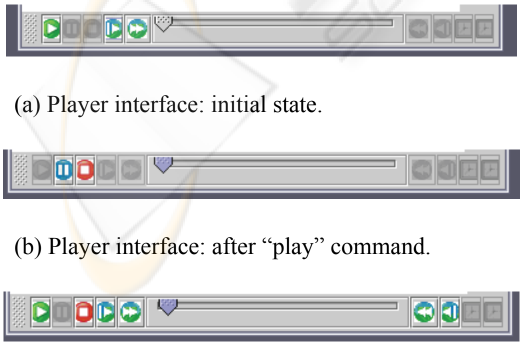
Figure 4 illustrates an example of hierarchy for the commands of the player component. In this hierarchy, if the user pronounces the word “watch” (use case “watch”), just the player VCR buttons will be enabled. If the “play” command is pronounced, all the buttons, except “stop” and “pause” will be disabled (for the application of video annotation, was defined that after the beginning of the video presentation, the sole available actions for the user would be the “pause” action or the “stop” action to interrupt the presentation through a voice command).

```
<?Xml version="1.0" encoding="ISO-8859-1"?>
<WordList>
  <UseCase tag="watch">watch
    <FatherNode root="false" tag="play">play
     <Child tag="pause">pause</Child>
     <Child tag="stop">stop</Child>
    </FatherNode>
    <FatherNode root="true" tag="next">next
     ...
    </FatherNode>
    <FatherNode root="true" tag="forward">forward
     ...
    </FatherNode>
     ...
    <FatherNode root="false" tag="stop">stop
     <Child tag="play">play</Child>
     <Child tag="forward">forward</Child>
     <Child tag="next">next</Child>
    </FatherNode>
  </UseCase>
  <UseCase tag="describe">describe
    <FatherNode root="true" tag="begin">start segment
     <Child tag="end">end segment</Child>
     <Child tag="region">add region</Child>
     <Child tag="comment">add annotation</Child>
    </FatherNode>
    ...

  </UseCase>
<WordList>
```

Figure 4: Extract from the hierarchy of commands.

One example of interface visual response to the voice command sequence is illustrated on Figure 5. After the initial stage linked to the "watch" case use (Figure 5 (a)), the user pronounces the "play" command and just the "pause" and "stop" buttons get enabled. (Figure 5 (b)). In the sequence after the "pause" command is pronounced, all the buttons, except the "pause" one itself, get enabled. (Figure 5 (c)). Notice that the enabled (disabled) components sequence follows exactly the grammar rules from Figure 4. Observe as well that the graphical objects associated to another use case (describes video segment) also remain disabled. The use cases are mutually exclusive, meaning that the manipulation of one of them disables the others.



(a) Player interface: initial state.

(b) Player interface: after "play" command.

(c) Player interface: after "pause" command.

Figure 5: Interface reactions for some voice commands.

6 CONCLUSION AND FUTURE WORKS

The paper has proposed a new approach to multimodal interface development with emphasis in the use of voice. This implies in evaluate the graphical interface in which voice will be integrated and, beyond this, knowing the voice characteristics while input modality. The major contributions of the work are:

1. Proposal of a process that suggest which activities must be followed to the voice inclusion in a GUI;
2. Proposal of hierarchy problem solving of voice command precedence through the use of XML files associated to rules grammar;
3. XML file model as the result of the hierarchy generation of voice commands precedence;
4. Proposal of a model parametrized multimode commands treatment;
5. The GRMMI environment implementation, that provides the solution and treatment for pronounce maintenance problems among the commands, as well as of a visual response to the application user of what can be said or done.

The GRMMI environment, beyond making the proposed inclusion process of the voice modality in a graphical interface valid, facilitates the implementation made by developers that wish to use voice in their applications, since it makes available a set of functions proper to input manipulation and treatment by voice and grammar and hierarchy automatic generation. The effort of development becomes less if compared to this work's. Using GRMMI, it is only necessary for application developers to identify the use cases, associated tasks and then use the generation module and the GRMMI engine in their applications (these are the steps of the proposed method).

The search for more simple, natural and intuitive human-computer interfaces has increased, mainly with the intention to reduce the user's problems and anxiety when using the system. The voice interface, once it is more natural to ht e human being, minimizes a little these initial problems and can facilitate and make the application learning process rich, as well as make its use flexible, in the meaning of allowing the access without using hands and/or eyes, access in small devices, generating a productivity gain. Besides, if the speech is associated to other modality, as clicking or drawing in digital images, the process can be a lot more interesting, since one of the modalities become more appropriated to tasks, often complementary.

From these considerations and obtained results, one can suggest as future activities that will continue this work: (i) submission to the multimode interface proposal to the evaluation by the users in order to measure the real gain relating to its use; (ii) possibility of choosing the recognizer language, that is currently only Portuguese; (iii) implementation of a multimodal output, allowing audio, text and image modalities integration; (iv) restriction of the possible words from the dictate dictionary, making it more in a context (e.g. if it is a medical application, a dictionary with medical expressions makes the recognition more precise and faster); (v) use of another recognition system that does not depend on training and (vi) implementation of treatment of the parametrized multimode commands.

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