Palette: A Paper Interface for Giving Presentations

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ABSTRACT
The Palette is a digital appliance designed for intuitive control of electronic slide shows. Current interfaces demand too much of our attention to permit effective computer use in situations where we can not give the technology our fullest concentration. The Palette uses index cards that are printed with slide content that is easily identified by both humans and computers. The presenter controls the presentation by directly manipulating the cards. The Palette design is based on our observation of presentations given in a real work setting. Our experiences using the system are described, including new practices (e.g., collaborative presentation, enhanced notetaking) that arise from the affordances of this new approach. This system is an example of a new interaction paradigm called *tacit interaction* that supports users who can spare very little attention to a computer interface.

KEYWORDS: Paper interfaces; presentation appliance; interaction design; physically embodied interfaces; tacit interaction.

INTRODUCTION
This paper introduces the Palette, an interface that presenters use to control electronic media without devoting attention to the computer. Presenting material to an audience is a ubiquitous aspect of business life. Presentation software for personal computers (PCs) is well designed for the task of creating and modifying content (e.g., slides). But this same technology can be daunting and awkward to use during times when we can not give it our fullest attention, such as when giving a presentation using electronic media. For example, it is quite common to see a talk where the audience must wait and watch the presenter manipulate the presentation PC, including searching through the file system for the presentation slides, fumbling over the controls (mouse, keyboard, or remote) to find a single slide, and trying to coordinate operation of other equipment (e.g., video tapes, room lighting).

The introduction of electronic presentation support gave us new capabilities, including multimedia content and removal of the nuisance of overhead projection (e.g., fan noise, misaligned or unfocused slides). However, we have lost the affordances of using physical slides (e.g., transparencies), including being able to select viewing material simply by picking up a slide, and being able to privately rearrange and preview slide sets before showing a slide.

The Palette (Figure 1) supports slide viewing using index cards. Presenters create slides with their chosen presentation software. Cards are generated from these slides with a thumbnail view of a slide, text notes, and a machine-readable code (e.g., barcode or Data Glyph [7]). Each card is encoded with file and slide information permitting presentation by simply sliding a card under the code reader located on a table or lectern. A presenter may keep the cards in hand or spread them out like paint colors on a palette for easy selection of whatever content should be shown next.

The Palette thus uses physical cards to represent presentation content. Physical objects have the property that we can perceive them both focally (for periods of

Figure 1. Palette cards are encoded with slide information permitting presentation by simply sliding a card under the Palette code reader. A presenter may compose a talk by selecting cards from one or more sets of previous talks.

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concentrated actions) and peripherally (for keeping track of an object's presence without being fixated on it). For example, the commonplace objects on our desks (e.g., clocks, phones) blend into the background of our awareness until we either need them or they call attention to themselves. This strategy of using physical objects for human-computer interaction (HCI) allows the presenter to work with electronic media and retain affordances lost by moving to a graphical user interface (GUI).

Tangible or physically-embodied user interfaces [2, 6] are a recent trend in HCI. Johnson, et al.[7] developed a paper user interface where users physically fill in a paper form on which computer-readable marks are printed to perform operations such as retrieving electronic files. A fax or scanner is used to enter the forms into the system and receive the results. The Digital Desk [10] uses video to observe paper documents on a desktop and allows workers to perform various computer-based interactions on the document text (e.g., retrieval of physical document location by content). More generally, Tangible Bits [6] are examples of the physical instantiation of GUI elements such as windows, icons, and handles in a sensor-based user interface. Applications include using physical objects for navigation of geographic data and controlling the flow of online data [4, 13], and controlling a simulation [14]. Systems such as Video Mosaic [9], PaperLink [1], and the Insight Lab [8] link online information with paper. The Insight Lab uses barcodes in support of analysis of video and audio data by linking paper notes to corresponding multimedia clips. The notes express evidence, patterns of evidence, and electronic whiteboard images created during the analysis. The Barcode Hotel is an interactive art exhibit that presents a shared physical and virtual space where users scan barcodes to modify virtual object behavior and movement [5].

The Palette integrates the use of physical and virtual objects and operations into a system where the physicality is well suited to the needs of the presentation task, including easy slide show initialization, having a private slide overview, preview and selection, keeping supporting notes readily available, and other needs discussed below.

We next describe the system through typical scenarios of its operation and then discuss our iterative, user-centered design and implementation. We describe our experiences of using the system in operation, including new work practices enabled by the system. The Palette is then considered with respect to its implications for HCI, as a specific example of a general interaction paradigm called tacit interaction, and we conclude with our future work in this area.

THE PALETTE AND ITS USE

The following scenarios for using the Palette illustrate the operation and main features of the system.

Before a Talk

Ed, a director in a large, multinational corporation, is planning a presentation for some visiting executives. They represent different divisions of their corporation and so have a variety of interests and levels of technical expertise. Ed does not need to author a new presentation for these visitors, because he often gives talks about his division and the projects going on there. Thus, Ed already has a large collection of Palette cards representing slides in various presentations that he and his managers have made.

To start assembling the current presentation, Ed draws on some recent materials created for a division-wide project review (Figure 1). There is a detailed set of slides for each project in the division that he may reuse. Ed plans to give only an overview of the projects in his 45-minute talk, but he will need to be prepared to discuss any project in detail. He goes through the project slides selecting just the slides labeled "Vision", "Goals", and "Status" for each project. He also consults a set of slides he presented at the last quarterly meeting, and selects some slides that describe how his division's projects relate to other activities in the company.

Once Ed has collected the slides he wants to present, he may decide to add some new material. The morning newspaper had a headline story relevant to the corporation's business, and so Ed has the story scanned and pasted into a slide in a new presentation. Ed runs the Palette Converter program to create a Palette card for that new slide. The slides are also stored in a central location at this time so they are accessible from the presentation room. Ed reviews what he wants to say in the talk and adds last-minute speech cues in pencil to a few cards.

Since these visitors are all fellow employees, Ed does not have to worry about revealing private corporate information. When Ed selects a slide, it is easy for him to preview and filter the cards before and even during the meeting to make sure he includes or excludes appropriate information.

Before the talk, Ed prints out several sets of the cards he plans to present, to hand out to the audience members to take home with them. He chooses to print only the thumbnail image and barcode for each slide. The cards themselves make useful handout material, either as cards or card images printed several to a page.

Making a Presentation

Right before the talk, Ed brings his deck of Palette cards along with sets of handouts to the presentation room, which is set up with a computer running the Palette software and driving a projection system (Figure 2). A barcode reader is connected to this system. Ed usually stands at the front of the room and has the barcode reader set up on a lectern. Ed often walks around the front of the room, making eye contact with different audience members, and carrying the cards he needs with him so he can advance the slides by walking back to the lectern or using a portable reader he keeps in his pocket.

Ed arranges his cards on the lectern in the categories he has chosen (e.g., overview slides in the center and topic slides off to the left). He starts with the overview slides, face up in

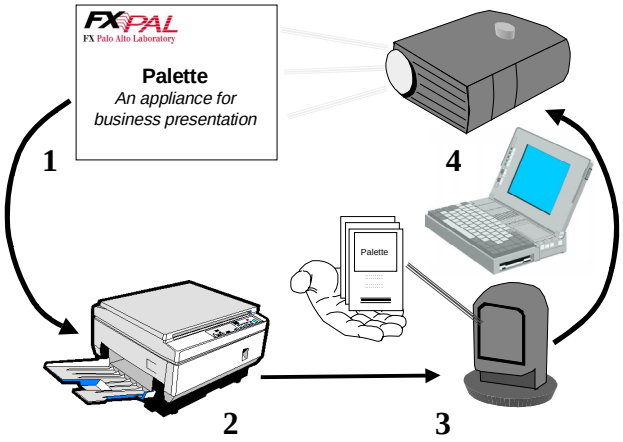

Figure 2. Presenters use their usual authoring software (1) and run the Palette Converter to generate cards (2) for use with a card scanner (3) to display the slides (4).

front of him, keeping them in the center. Even though the cards represent slides from different presentation files, Ed does not have to think about that; each card has enough information to identify the file and the slide within that file. As he finishes talking about a slide, he turns it face down and adds it to the pile of completed slides, in the same way that people stack overhead transparencies. Different spatial arrangements of presentation content are possible, giving Ed a flexible overview of the material.

When he learns from his audience that they attended a detailed seminar about Project X, Ed pulls those slides from his deck and sets them aside to avoid boring the audience. As projects requiring greater detail and questioning arise, Ed switches to the side piles, returning to the overview when detailed discussion concludes. Ed makes notes of the discussion on the back of each card for later use.

At the end of the talk, there is a question and answer session. Susan, one of the visiting executives, has questions about a graph Ed displayed earlier. She asks "What causes that blip in the graph you put up on demographics?" While Ed flips back through the slides looking for the demographics chart, Susan has already found her copy. Susan uses a wireless pen-style reader that is conveniently available to the audience, changing the display to that slide. As further question and answer proceeds, Ed spreads out the related slides face up in front of him, so he can quickly recognize and pull slides that will help him address the questions.

Follow-up Activities

Ed brings his annotated deck of cards back to his office. He later refers to them when summarizing the meeting for his notes and placing action items in his calendar. Each of the attendees may use the handout cards in a similar manner, and they can also incorporate those cards into their own presentations about the results of the meeting.

USER-CENTERED DESIGN FOR PRESENTATION

The current form of the Palette resulted from an iterative process that involved several stages of user study and prototyping to inform the design. In the beginning we had a general vision of being able to make presentations more physical: we compared the presenter with a painter using a palette of colors.

Observations of Users of Presentation Support

The palette vision lead us to observe and interview 14 people giving presentations, to find out which presentation media they prefer, how they like to control their presentation material and equipment, what number and duration of slides they presented, what events occurred to affect the order of the presented material (e.g., questions from the audience), and how they dealt with those events. Once we focused on the idea of replacing GUI control with a more physical mechanism, we paid particular attention to where presenters stood and traveled during the presentation, and what they held or carried. People observed were Xerox staff (managers, researchers, and summer interns) and participating visitors (executives and researchers).

Almost every presenter manipulated some representation of their slides, usually a printed copy of the transparency or electronic slide. They all touched some kind of control device for changing slides, such as a keyboard or mouse for electronic slides, a remote-control for 35-mm slides, or the slides themselves for transparencies. Presenters who used multiple media such as videos controlled that part of the presentation indirectly, by giving verbal commands to an unseen technician.

Most presenters had media other than the slides that they consulted or interacted with during a presentation, including notes written on copies of the slides, notes written on cards or sheets of paper, models to demonstrate, quotations or tables to consult, or materials to hand out during the talk.

Our observations and interviews of people giving presentations identified the following needs that a new presentation support mechanism should accommodate.

Slide initialization. We commonly noticed a long nervous pause in the meeting flow while a slide set was being started, especially when multiple presenters were speaking consecutively. If the slide viewer was not initialized beforehand, presenters manually navigated the files to find their talk.

Slide manipulation and overview. Presenters preferred systems in which they could directly control the change of slides (e.g., transparencies) over systems in which they had to issue an indirect request for the next slide (e.g., verbally). In order to answer a question, a presenter sometimes needed to search for a particular slide. Searching through transparencies was sometimes not done strictly sequentially (i.e., by fanning the slides out and scanning the overlapping title lines); sequential search was the norm for pre-ordered media such as 35-mm and PowerPoint slides.

We did, however, observe one individual use the 'Slide Sorter' view of PowerPoint to provide a selectable overview of slides for questions and answers at the end of a presentation. This usage provided a useful overview even though it had disadvantages: the thumbnails of the slide sorter were low resolution images and difficult to see, the speaker notes were not available, the audience observed the presenter manipulating the internal view of PowerPoint (i.e., menus and toolbars), the audience viewed all thumbnails (even those intentionally left hidden or skipped), and the presenter had to leave the 'Slide Show' presentation view of PowerPoint to see the 'Slide Sorter'.

Slide re-ordering. Presenters indicated a need for re-ordering slides to change emphasis, fit a particular time slot, and omit certain material. With sequential presentation media, if a presenter needed to skip a slide due to lack of time or audience interest, it was common for the audience to see the slide briefly as the presenter passed it by.

Presenter Mobility. Presenters often walked around to engage the audience, gesture at the screen, and use the presentation-control equipment. Some presenters carried their speech notes around with them, so they could refer to notes without staying at a lectern. Many speakers changed their physical position in the space for different activities (e.g., presenting, question and answer, discussion).

Audience (public) and presenter (private) views of material. We noted a number of actions that made the audience wait and watch the control of the presentation mechanics, including: loading slides, skipping slides, exiting to the desktop at the end of a talk, viewing cursor movement for hyperlink navigation and controlling multimedia content, and using the wrong control because of a misunderstanding where the presenter was in the slide sequence or because of forgetting infrequently used controls.

We also observed private views used by a presenter, including reading and making annotations on copies of slide or notes, using notes or transparencies to look ahead or back at slide, and controlling other media (e.g., software demonstration, audio/video equipment, room lighting). Our observations and interviews indicate that if a presenter consulted a private view such as a set of speech notes, they needed to coordinate it with the public material. Of the media seen, overhead transparencies offered the most straightforward coordination mechanism, since the act of moving the old slide and replacing it with the new exposes a separator sheet that is suitable for storing notes for that slide. Presenters using electronic slides that could be flipped forward and backward using control keys often experienced delays in then searching through notes to find the matching place.

Use of hands. Many presenters like to keep their hands occupied. If they are not doing things directly related to the presentation, such as pointing or changing slides, they often fiddle with other things. More than one presenter said they like to keep their hands busy to "burn off excess energy".

Sharing material. Frequently, presenters hand things out to the audience (e.g., full slide sets, particularly interesting slides, or a physical artifact). Full slide sets would sometimes be handed out at the beginning or end of a talk. We have seen a particular slide or artifact handed out or displayed only when the talk reached the appropriate point.

Comparing Presentation Support

The Palette responds well to these presentation support needs. Table 1 compares how the Palette and commonly used presentation methods address these issues, including desktop style PCs (e.g., window-icon-menu-pointer), remotes (e.g., a remote mouse with control buttons), 35 mm slide projection, and document projection (e.g., transparencies and document cameras).

A presentation should start immediately without the presenter having to navigate through file structures and commands. The Palette cards have all the information for initializing the presentation, unlike desktop interfaces and remotes. Projected documents and 35mm slides (once properly adjusted for projection) also physically incorporate the static part of slide content needed for presentation.

Palette cards represent the slide content for the presenter and provide direct manipulation for slide changing. The cards do this in a manner supporting an overview of slides that can be rearranged at any time. The desktop, remote, and 35mm slides all require an intervening control device of some kind, making re-ordering content difficult. While overview is possible to some degree with desktop systems (e.g., 'Slide Sorter' discussed earlier) and to a lesser degree with sophisticated remotes, a display screen is much more limited by total size and resolution than a deck of high quality printed cards. The cards are small enough to be arrayed on a table or flipped through in hand for searching.

Feature Supported	**GUI/Desktop**	**GUI/Remote Control**	**35mm**	**Transparency/Camera**	**Palette**
Show initialization	Must navigate	Must navigate	Yes	Yes	Yes
Direct manipulation	No, uses mouse/ keys	No, uses mouse/ button	No, uses button	Yes	Yes
Slide overview	Limited by display	Limited by display	No	Yes	Yes
Slide re-ordering	Limited by input device	No	Awkward	Yes	Yes
Public/private views	Needs multiple windows	Limited by display	No	Yes	Yes
Presenter mobility	Limited by I/O devices	Yes	Limited by equipment	Limited by equipment	Yes
Use of hands	Limited by input devices	Yes	Yes	Yes	Yes
Sharing	Limited by I/O devices	Must share controller	Must share controller	Yes	Yes
Electronic media	Yes	Yes	No	No	Yes

Table 1. Comparison of Presentation Support Systems.

The system control should be mobile, so the presenter can hold it in hand and carry it around while talking, but not be so bulky that s/he is kept from using other objects (e.g., pointers). Using a detection mechanism such as commonly available barcode readers (portable or hands-free) to scan barcodes on the card provides mobility. A card gives the presenter something to hold that provides presentation control, assists them in what they say, and does not cause a distraction to the audience (since the card is only active when under the reader and repeating a card causes no problems). Systems with control devices fixed in a location require a presenter to move back to that location for slide change. The presentation remotes and portable barcode readers avoid this situation.

Presentation support should let the presenter control the accessing and display of public material directly while also keeping a synchronized view of the related private material. The less that the presenter has to do to keep these views together, the better. Systems with separate views of control and private material (desktop, remotes, and 35mm slides) are somewhat more limited in this capacity.

Finally, the audience should be able to use the distributed material to frame questions. The cards are aesthetically appealing when printed with high quality printers, hence easily readable in fine detail, and are shareable with other presenters and the audience.

User Study for Palette Configuration

Prospective users of the first Palette prototype were studied to identify the physical configuration of the design, including the layout of the index card and the kind and orientation of scanning device that will access identifiers on the cards. A variety of photographs of barcode readers with different scanning and physical characteristics were given to users, including forward, downward, and upward looking scanners, a sliding strip scanner, a pen scanner, and a mockup of a "wearable" scanning device. Two mockups of card layouts were constructed that contained a thumbnail of a presentation slide, a barcode, and text of presenter's notes: all three elements on one side, and thumbnail and barcode on one side with notes on the other. Users were then interviewed to determine their preferences and enact how they would use the actual scanners and cards represented by the mockups. The seven people observed were all Xerox researchers who were frequent presenters.

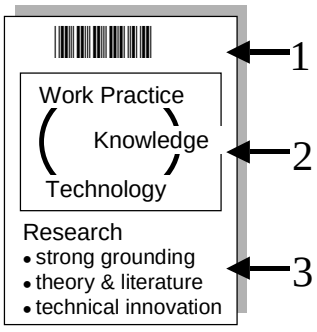

Figure 3: The preferred card configuration identified by presenters contains, all on one side, a code (1), thumbnail image (2), and speaker notes (3).

The strongest preference was for waving the index card at the barcode reader. However, for less formal, round-table meetings, pen-based systems received strong interest. The motion of reading the barcode must be quick, comfortable, and sure. Consequently, we determined that the first Palette installation include an omni-directional hands-free scanner (to give the greatest location choice and flexibility), and a pen system (to test different presentation scenarios). Two standard templates for card layout for each device were preferred: all elements on the front of the card, and also barcode located on back, thumbnail and notes on front.

EXPERIENCES IN OPERATING THE PALETTE

A study was made using the Palette prototype and equipment where presenters were given an identical presentation task. The 13 people observed were all Xerox employees (research and support staff) who represented a mixture of frequent and infrequent presenters. The goal of this study was to determine actual position and orientation of the reader and arrangement of Palette object elements (identifier, thumbnail, and speaker notes) needed for deploying the system in our own company conference room. We observed how many times a card was flipped or turned by a presenter and the number of times the scanning device failed to read a card. Four sets of four cards in each of the major configurations of elements were used (i.e., three sets with two elements on one side and one on the other, and one set with all on one side). We also noted presenter activity (e.g., gaze and what they did with the cards after using them). Finally, we asked people what card arrangement they preferred from all possible arrangements.

We found that the one-sided card arrangement resulted in by far the fewest card motions and that a majority of people preferred this arrangement (Figure 3). We also noted that there was quite a bit of variation for other styles that the system should accommodate (e.g., horizontal cards, not showing the speaker notes). Speakers who spread the cards out in an orderly spatial arrangement are able to quickly select a slide in response to a question. Keeping the cards in a stack or in hand requires the speaker to thumb through the cards looking for the correct one.

The Palette has been put into use in our own conference room. We have found one situation where a portable GUI system might be considered more appropriate than the Palette, namely in addressing very last minute changes. Like other presentation methods (e.g., transparencies), using the Palette enforces a separation between slide authoring and presentation: the cards must be fabricated. Consequently, there might not be time to print a new card. While it is usually not wise to make such late changes to an important presentation, we have found that this situation may be accommodated with the Palette by a simple workaround. If the change is to an existing slide, the Palette card still functions correctly (i.e., nothing has

changed that affects the encoding). If material is to be dropped, the card is just omitted. If new material is to be added, it should be put at the end of a presentation file. A temporary card may be easily fabricated by hand. We have preprinted, adhesive barcode labels for this purpose.

IMPLICATIONS ON PRESENTATION PRACTICE

In addition to providing the affordances we expected, we are finding that having a presentation medium with new capabilities is enabling new practices.

For example, when the Palette is used, the machinery of presentation initialization and slide selection is not visible and, hence, does not impede collaborative presentation (i.e., talks involving material and ideas mixed from several people). The ability to very quickly share, collectively preview, and discuss cards without disturbing the flow of a meeting permits an atmosphere for 'co-presentation' (Figure 4). We have observed this practice happening as spontaneous and brief discussions that arise between presenters during normal pauses in meeting flow (e.g., when questions are asked and at end of a topic).

We are also observing some changes in notetaking and new uses for paper notebooks. Palette cards are often annotated with revisions or used to record interesting questions, comments, or other relevant information. We have seen a paper notebook being used in place of cards. Pointers to supplemental material such as supporting slides, including *ad hoc* sketches and Universal Resource Locators (URLs) for relevant Web pages, are kept in the notebook along with a barcode link to the online information.

IMPLEMENTATION

The selection of barcode reading for card sensing is perhaps the key factor shaping the current Palette implementation. Our rationale for this decision is based on the following reasons: (1) barcode-reading is a mature technology, for which many kinds of devices are widely available that provide good, robust performance in real-world settings; (2) prototyping with barcodes gives us a migration path to other marking technologies (e.g., glyphs).

Another choice that affected the current implementation is the selection of Powerpoint as the supported presentation software. Our rationale for this decision is based on the following reasons: (1) Powerpoint is a mature application that has a large user community; (2) the presentation authoring and slide viewing functions are accessible programmatically through an application programming interface.

Performance tests conducted with our prototype support these system choices. The test configuration was a Pentium II (333 megahertz) running Windows NT 4.0 with 130 megabytes of memory and using a Symbol LS9100 barcode scanner. By adjusting barcode type and size, misreads of barcode scans were reduced to an average of 1 miss every 25 tries. We scanned sets of 100 cards manually in the same manner a presenter would use the device (with the exception of moving as fast as possible) and observed the

Figure 4. Co-presenters decide how to continue discussion based on questions and available material.

Palette response. Times for slide changes using Powerpoint depends on the slide content size. The test presentations were graphics intensive files, averaging 11 slides stored in 2 megabytes files. The average time in which slides from within one file could be switched on the presentation display using the Palette was observed to be 0.83 seconds. Using keyboard control to switch to previously displayed slides requires some small fraction of a second. However, it is difficult to notice or quantify a difference when switching to new slides when compared to the Palette. The average time for consecutively and cumulatively loading slides from 12 unopened files was 2.18 seconds per file. The average time for using the Palette to switch between slides from different files already opened in PowerPoint was 1.31 seconds. This multiple file access is not supported by the Powerpoint slide show viewer, and hence is not comparable with the Palette.

The resulting Palette system is implemented as two programs running under Window 95/NT: the *converter* and the *controller*. Before a presentation is given, the converter is used to create Palette cards from the presentation. The controller runs during a presentation; it is responsible for accepting scanned input from the codes on those printed cards and for displaying the appropriate electronic slides.

The Palette converter is a standalone program that reads a file created by presentation authoring software (currently PowerPoint) and creates a document (currently Microsoft Word) containing the content of the presentation in a layout suitable for printing on card stock. Each card represents the content of one slide and contains up to four elements: a thumbnail of the slide image, speech notes, the slide number in the sequence of the presentation file, and a computer readable identification code (i.e., barcode) indicating the presentation and number for this slide. The converter resizes and positions these elements in the output document so that the image will fit neatly and readably on the card stock. A number of different layouts are provided based on our user observations of card use. The converter also saves a copy of the presentation in a central location (with a filename consistent with the card identification

code) and records its actions in a central log. The Palette converter is implemented in Visual Basic for Applications (VBA), using Visual Basic primitives to extract elements from PowerPoint presentations and manipulate them in Word. After the converter runs, the printed cards are used to control a presentation through the Palette controller.

The Palette controller uses a client-server architecture. The client accepts input from a barcode reader; the server carries out commands to operate PowerPoint.

The Palette client is implemented in Java. The client runs remotely and communicates with the server PC through a TCP network interface. The client listens to input from a barcode reader attached to the keyboard port or to the serial input (RS232C) port of the client PC. The data from the reader includes the filename of a PowerPoint file, slide number, or a special control command such as merging multiple slides into one composite slide, changing background color of slides, or stopping a presentation. The client translates the barcoded data into presentation-control commands and sends them to the Palette server.

The Palette server is implemented in VBA. The server runs on a PC and controls a PowerPoint application running on the same PC. The video monitor output from the server PC drives a presentation display screen. The server waits for network connections from Palette clients. Once a client connects, it sends presentation control requests to the server. Visual Basic primitives allow the server to control PowerPoint presentations. For example, the server can direct the presentation to load a specified PowerPoint file, jump to a specified slide, go to the next or previous slide, stop the PowerPoint slide show, and so on.

One consequence of our implementation approach is that manual overrides and fallbacks for equipment problems are well supported. At any time a presenter may use the keyboard/mouse interface to PowerPoint. If the cards are printed with sufficiently high quality (e.g., 300 dpi), the cards provide the same resolution as PowerPoint images, and thus can be used with a document camera as a fallback if a computer-projection interface fails. Finally, if all projection or electrical power fails during a talk, the cards can be used as speech notes for the presenter to continue giving the talk without technological support.

TACIT INTERACTION AND FUTURE WORK

The Palette is one of several efforts to explore a new human computer interface paradigm; we call the paradigm tacit interaction. Tacit interaction combines two concerns: technology should engage a wider range of human perception and it should enable a larger degree of low-intentional interaction than is found in current interfaces. Within this paradigm, the Palette explores ways to "re-physicalize" the human computer interaction (HCI) and thereby allow the user to distribute tasks to less intentional, less intellectual modes of action.

The need for new interaction paradigms, such as tacit interaction, has been growing as the traditional graphical user interface develops and reaches its limit of usefulness. The problems may be classified as concerning intentionality and attention.

Intentionality. Office workers experience an increased need to shift back and forth between multiple applications and communication appliances, but most applications assume the user to be ready and dedicated to whatever interaction they engage in, i.e., these applications appeal to high-intentional interaction. For example, the print spooler tells the user that a print job is ready to print by popping up a modal alert, blocking the user in whatever else s/he was engaged in to "release" the computer from the alert. Many of the devices and appliances we are surrounded and serviced by make similar demands. Rather than forcing a computer-like multiplexing scheme onto the user, we suggest we let the technology adapt to the human way of dealing with parallel demands: by distributing the tasks to automatic and semi-automatic modes of action we involve more of our motor skills and thereby more of our body. The open problem and challenge to HCI is to understand how to "re-physicalize" parts of the human computer interaction, and the Palette is only a first step.

Attention. The focus of our perception is becoming increasingly overcrowded by competing demands for our attention [15]. For example, Microsoft Powerpoint 97 has a pop-up/slide-out menu in its Stage Manager tools (used during a slide show) that has 29 unique functions, including three additional windows for presentation control (see also [3]). Also, in many presentation rooms, there are controls for audio, video, room environment, and commonly a dedicated PC, as well as an audience, demanding a presenter's attention. Rather than continuing to fill up the user's focal space even more, the tacit interaction paradigm suggests we utilize a wider range of perception and include also some peripheral modes of taking in the environment. The Palette offloads the user's attentional focus in several ways, partly by relieving the user from the entanglements of a computer desktop and partly by making the essential objects for manipulation physical, thereby providing all the affordance of the well-known index card. The Palette expands in this way on our previous work on peripheral awareness in the AROMA system [11, 12].

Technology we have developed for tacit interaction currently involves three interface approaches that address off-loading activities from an over-taxed cognitive system to under-utilized areas such as the peripheral ranges of our senses and the motor system.

First, we reduce the need for keeping in mind complex steps for explicitly invoking system operation by using physical objects as tangible representations of interface content or control (physicality strategy). For example, placing a Palette card on the lectern to select a slide is more easily accomplished than finding and adjusting a pop-up/slide-out menu on a control window - in general we observe that direct physical action can be more efficient and reliable than a GUI style interaction. Second, we

reduce the need for cognitively demanding decision-making by reducing choice (the appliance strategy). For example, by packaging the Palette as an appliance we provide a powerful, self-contained device suited for a specialized task, namely, selecting and displaying information for an audience. Third and last, we further reduce the need for decision-making by deriving decision data from the environment (the sensor strategy). Sensor technology enables us to detect what actions are in progress and thus, aids the system in responding to a user's intent. While the Palette uses sensors to detect the identity and action a presenter makes with a Palette card, the decision-making aspect has not yet been explored in detail in the system.

We are now focusing our work on long term deployment of the Palette in a busy conference room of a business organization. This experience will help us to refine our physicality strategy as a tacit interaction method and should allow us to generalize the concept to other applications (and hence tasks) that should be accomplished in a similar manner. Such results will be integrated with our findings on peripheral perception and low-intentional interaction as they were explored in the context of the AROMA system. In parallel we are expanding the design space to further include the sensor strategy.

CONCLUSIONS

The Palette is a new interface that allows a user to control electronic slide shows without having to handle a computer and thereby deflect attention away from the primary task of communicating to an audience. The design for the system is based on our observation of presentations given in a real work setting. Using an interaction paradigm based on direct manipulation of physical objects representing slide content overcomes current interface limitations that overtax our focal perception and demand too much of our attention. Our use of the Palette has produced new kinds of presentation work practices (e.g., collaborative presentation) arising from the affordances of a new approach.

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