Understanding and Augmenting a Paper Arrangement-Based Method

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Abstract
I investigate the practices of affinity diagramming, a method for qualitative data analysis and idea generation, and the factors that lead HCI researchers and practitioners to usually perform it on paper rather than on digital devices. Based on my findings, I propose that Ubicomp technology can be used to create an *implicit interaction* system that allows users to preserve their preferred practices, while offering the benefits of a digital system. Initial prototypes have been built; a more complete prototype system and evaluation of the solution remain to be completed.

Author Keywords
Affinity diagram; implicit interaction; augmented paper

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Despite the central role information and computing technology (ICT) plays in most professions today, certain important work processes are still overwhelmingly performed in the physical world and without computer support. These work processes take a number of forms, one of which is arranging pieces of paper (sticky notes, photos, drawings, etc.) on a

surface such as a wall, a board or a table. Many decades of attempts to develop ICT devices and applications to support these tasks have done little to change such common practices.

Figure 1: Affinity diagram example. Photo © Sean Munson.

One particular paper-arrangement process is *affinity diagramming*, a method that is used in the fields of Human–Computer Interaction (HCI), design, anthropology and management [1]. In affinity diagramming, users cluster entries written on paper cards or sticky notes to form groups of related items (Figure 1). Desktop applications and touch screen systems for doing affinity diagramming exist, but do not appear to be widely used [4,8].

I propose that by augmenting the paper-based affinity diagramming process with computer support based on implicit interaction (user actions not primarily intended as computer interactions, but understood as input by the system) [12], the combined system could offer users improved support for their work without compromising the advantages of the paper-based process. In my doctoral research, I seek to:

- Provide a better understanding of the current practices around affinity diagramming, and identify which aspects of these practices could benefit from computer support
- Offer novel implicit interaction-based concepts and prototypes aimed at achieving those benefits
- Determine whether the prototyped designs are effective at supporting the affinity diagramming process and suitable for use in real-world contexts, through qualitative and quantitative test and user studies

I expect to accomplish these contributions by answering three corresponding high-level research questions.

Research Question 1

What are important characteristics of affinity diagramming as currently practiced among HCI-oriented researchers and practitioners?

Related work

Different affinity diagram variations are explained in textbooks and instruction manuals [1,2,7]. However, this documentation is primarily prescriptive rather than descriptive, and it is unclear how well it characterizes actual work practices.

To my knowledge, empirical studies of affinity diagramming are limited to two papers, Judge et al. [8] and Geyer et al. [4], who both observed mostly novices working in staged sessions. While these studies represent valuable work and interesting findings, studying novices is a limitation, and the process they looked at doesn't exactly match any of the models from the literature. My work supplements and extends these studies.

Approach

As this research question is fundamentally qualitative, I took a qualitative approach based on the contextual inquiry method [1], using observations and interviews. Due to the difficulty of arranging observations of real-life affinity diagramming sessions, I have so far relied mainly on retrospective interviews and artifact walkthroughs.

To help inform early concepts and to guide further study, informal interviews were held with seven

participants about their affinity diagramming practices and experiences [6]. I later conducted semi-structured interviews with fourteen participants. These interviews lasted between one and two hours, with 90 minutes as the default. In addition to the retrospective topics in the interview protocol, I asked participants whenever possible to share material from their work, and used that as a basis for conversation (artifact walkthrough). The data was analyzed using qualitative methods.

Results

Some high-level findings from the interviews include a classification of variations of affinity diagramming and the purposes they serve, a description of the stages of the process (identifying the transitions between paper-based and digital representations as particularly problematic), properties of the physical artifacts that participants leverage to increase the flexibility of the representation, and problems and limitations they face. These findings inform my attempt to answer RQ2 and provide support for the decision to attempt a solution based on paper notes.

Research Question 2

How can implicit interaction-based augmentation be applied to the paper-based affinity diagramming process in a way that fits with current practices?

Related work

Previous efforts to support affinity diagramming have mainly relied on desktop PCs[1] or on large, shared screens. Examples of the latter include The Designer's Outpost [10], The Designer's Environment [14], the system by Judge et al. [9], the Affinity Table [4], and Affinity+ [3].

None of these prior efforts have attempted to augment the paper-based process. Rather, they have moved it onto a touch screen or other interactive display. My approach has more in common with previous work on augmenting paper to bridge information in the physical and digital world, such as the Digital Desk [16], Collaborage [11], and the CAM system [15]. In my work, I am applying augmentation approaches similar to these to the affinity diagramming process.

Approach

To come up with a technological solution that fits with current practices, I am employing an iterative UCD process. I initially brainstormed a number of ideas for ways to enable computer augmentation of the paper-based affinity diagramming process. I created sketches and storyboards demonstrating particular use cases, and collected feedback from experts and potential users. Based on these ideas I have overseen the creation of multiple prototypes [5].

Proposed solution

The essential element of the system is capturing the content and position of each note on the wall. Each note is tagged with a unique ID, stored in a QR Code. A camera pointed at the wall can then recognize the 2D barcodes. If the notes are prepared in advance on a computer, the content of each note may simply be looked up in a database using the ID. If the database does not contain the content, the best available picture of the note taken by the camera can be used.

[1] e.g. http://www.skymark.com/pathmaker/tour/brain.asp; http://allmyapps.com/apps/stickysorter-organize-notes; http://www.benjaminkoh.com/AffinityTool.html

Figure 2: Diagram of proposed solution.

The system (Figure 2) takes advantage of two types of cameras; a stationary, high-resolution camera mounted on a tripod (a) to capture the whole wall, and the handheld cameras in mobile devices such as smart phones (b) and tablets (c). The stationary camera is connected to and controlled by a computer (d), and snaps photos at regular intervals during the affinity diagramming sessions, thus providing an incomplete (due to occlusions and barcode recognition failures) record of the locations of each note throughout the process. Finally, a projector (e), connected to a computer running a system client and calibrated with the camera, is used to overlay output directly on the wall and onto the physical affinity diagram.

Prototypes

The first implemented prototype (Figure 3a) addressed one of the issues identified in the initial interviews: finding notes. The idea was to allow users to locate notes by text search using an augmented-reality interface on a mobile device. The user would enter a search string on the tablet. Using the tablet's webcam, she could then hold up the tablet and "pan" across the wall to see the sticky notes. When the barcode of a selected sticky note was in the frame, the application highlighted the barcode on the tablet view in bright orange.

A subsequent prototype (Figure 3b) addressed the issue of seeing more context and information about a note. The interaction was similar to the previous tablet prototype, where the user would hold up the tablet to the wall to capture certain notes with the camera.

A third prototype (Figure 3c) also addressed the search problem, but instead of using a tablet to scan the wall for the notes wanted, the search was done on a smart phone and the notes were highlighted directly on the wall by a projector (calibrated with a stationary camera tracking the positions of the notes).

These prototypes implemented very limited features; they were not capable of supporting the affinity diagramming process as a whole. In the next stage, I intend to put the separate pieces together and improve the robustness and performance of the system so it will be possible to actually use it for a whole affinity diagramming session. This should make it possible to run more comprehensive user studies and thereby address RQ3.

So far, one part of this integrated system has been implemented, a web-based tool to import data from text documents into our affinity database, and produce printable affinity notes with 2D barcodes.

Figure 3: Three initial prototypes.

Research Question 3

What effect does implicit interaction-based augmentation have on the paper-based affinity diagramming process?

Related work

While methods to test traditional usability measures such as speed and accuracy/error rate are well known, the ability of a system to support creative and reflective processes can be harder to evaluate. Of the prior systems to support affinity diagramming and related techniques, Designers Outpost [10] and Affinity Table [4] were tested through qualitative user studies. Other tools to support creative collaboration, such as CAM [15] have been studied similarly. Supplementing this approach, Shah et al. [13] propose dimensions and metrics that can be used to quantitatively study performance on creative tasks. I intend to employ both qualitative and quantitative methods in my evaluation.

Approach

I anticipate that I will perform three types of studies. The first is standard usability tests such as cognitive walkthrough and think-aloud evaluation. These tests are part of the iterative design process, and have already been performed (to some extent) with the existing prototypes.

The second type of study is to test whether the augmentations offer measurable improvements to specific parts of the affinity diagramming, and which interaction types and UI designs are most effective. I will run quantitative, controlled user tests comparing different affinity diagram augmentations, using the traditional non-augmented paper-based version as a baseline. I will measure the effect of providing the proposed augmentations on how well participants perform certain tasks, such as finding a note or a set of notes matching some criterion, giving a summary of the content of the diagram, or grouping a set of unorganized notes into an affinity diagram and generating ideas.

With the third type of study, I intend to examine the effect of the proposed augmentations on affinity diagramming practices and group dynamics. For example, whether one person's use disrupts the work of others, or if social practices evolve around using it collaboratively; where in the process people use it, and if new patterns of working with affinity diagrams are created. These will be primarily qualitative, observational studies, where groups of experienced affinity diagrammers work together in realistic (although staged, because of the scheduling difficulties that would otherwise be involved) affinity diagramming sessions. I will observe and record them as they work and interact with the prototype systems, and interview them about their impressions and experience afterwards.

Biography and Acknowledgments

I am a doctoral student at the Zurich People and Computing group (ZPAC), led by my advisor Prof. Elaine M. Huang. My background is in Computer Science and HCI, with a master degree from Carnegie Mellon University. I began the PhD program in fall 2010, and currently expect to complete by EOY 2014.

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