Tabletop AgilePlanner: A Tabletop-Based Project Planning Tool for Agile Software Development Teams

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Abstract

This paper introduces the Tabletop AgilePlanner, an advanced prototype that applies tabletop technology to support collocated and distributed agile planning meetings. By introducing the novel tabletop-based project planning tool, this paper contributes to the agile and tabletop research in threefold: First, it provides real world experience of using a digital tabletop to solve practical problems, not just a demonstration of tabletop capabilities. Second, it shows a multipart usability evaluation that exposes the benefits and limitations of using digital tabletop to develop project planning applications. Third, it expresses some trade-offs that impact the design of the Tabletop AgilePlanner. Since the design experience and trade-offs come from a real practice, this paper provides insights into the construction of real world tabletop applications.

1. Introduction

Digital tabletops have been widely applied to prototyping groupware applications. Mahmud reports a new gaming experience design based on augmented tabletops [1]. Other tabletop application prototypes involve the interactive art design [2], education [3] and social services [4]. Many of these applications primarily aim to demonstrate the capabilities of tabletops rather than being practical application from a real world domain. Moreover, as practical group collaboration, an agile project planning meeting is not yet supported by tabletop applications.

An agile planning meeting (see Figure 1) is an important group activity that drives the agile software development processes. In a traditional, collocated agile planning environment, participants sit around a physical table and discuss future project tasks using pen and paper to write "story cards" – a paper artifact that records a task's name, description, owner, and expected duration. Group collaborations involve editing (writing and erasing) story cards, passing cards from one collaborator to another, rotating cards for proper orientation and sometimes tossing cards between two attendees who may be sitting far apart. Planning meetings conducted in the described way feel natural for agile teams. However, this attitude is challenged when teams are distributed across multiple sites.

In a distributed agile planning meeting, the natural interactions visible in traditional collocated meetings are hardly supported. Due to the lack of a physically shared meeting space, it is very difficult for remote meeting attendees to focus on the same story card and follow discussions that are centered around these artifacts. Moreover, the attendees may not be aware what is happening at any given remote location. Team communication is thus hindered and planning meetings are not as effective.

A possible solution to the collaboration problems is to set up a virtual meeting surface which shows a real-time scenario, highlights story cards that are currently the focus of the discussion, and visualizes user interactions with the shared artifacts. Some agile researchers have come up with project planning tools, such as MasePlanner [5] and XPWiki [6]. However, the meeting setups using a vertical screen and a single mouse/keyboard per site result in some drawbacks when supporting group collaborations [7]. For example, a PC monitor is often too small to allow many collaborators to work together and to provide the group a readable workspace. PC projectors can be utilized but

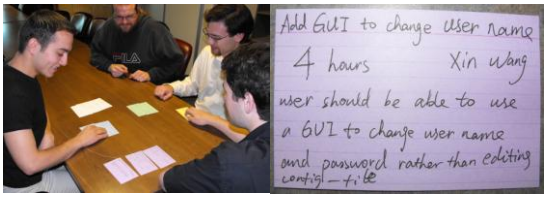

Figure 1. Agile planning scenario and paper card

then the shared surface is out of reach for direct touch interactions of participants sitting around a table. Moreover, when using a conventional personal computer only a single keyboard and mouse interaction is allowed at one time. Thus, to conduct a project planning meeting, group collaborators have to change the mouse/keyboard control privileges frequently or assign access to mouse/keyboard to a specific meeting participant.

Utilizing digital tabletops to support agile planning meetings will effectively enhance agile planning experiences and solve the problems mentioned above. The large, horizontal, and tangible screen of a digital tabletop enables participants to interact simultaneously by using their fingertips. This maintains the natural behavior observed in a traditional pen-paper based agile planning meetings. The benefits of distributed digital tabletops have been well substantiated by several research prototypes [8, 9, 10]. The related "mixed presence" [11] studies encouraged us to explore an agile planning tool using distributed tabletop technologies.

This paper reports on our advanced prototype – Tabletop AgilePlanner – and the engineering trade-offs that we made to accommodate user requirements. It utilizes digital tabletops featuring touch-sensitive horizontal screens to support collocated and distributed agile planning meetings. Our work contributes towards agile software engineering as well as tabletop application development. First, the utilization of tabletop technology to enhance distributed agile planning is, to the best of our knowledge, new. Our novel prototype enriches the body of tabletop applications and provides a new alternative to conducting agile planning meetings. Second, the evaluation of Tabletop AgilePlanner provides insights on the benefits and limitations of table-based planning applications that might be generalizable to other domains. Last but not the least, our design and evaluation of Tabletop AgilePlanner reveals some trade-offs between basic tabletop research and a real world tabletop based system.

This paper is organized as follows: Section 2 discusses related work that supports the development of our prototype. Section 3 introduces the design and implementation of Tabletop AgilePlanner. Section 4 discusses our evaluation and results. In Section 5, the trade-offs in the prototype design are assessed.

2. Related Works

Our system relates to work within distributed table-top design, multi-touch, and interaction mechanisms.

Distributed tabletops are becoming a main stream of tabletop technology. With the wider spread of digital tabletops and tabletop applications, an increasing number of team interactions will be held by remote collaborators using distributed digital tabletops from different locations. Tuddenham and Robinson [7] systematically reviewed former studies of distributed tabletops. They provide a guideline to facilitate distributed tabletop development and argue that these types of applications should have:

- A large horizontal display
- Consistent virtual seating arrangement
- Direct input mechanisms
- Digital artifacts that could be moved and reoriented
- Concurrent interactions
- A channel to talk with each other

While developing our tabletop-based AgilePlanner, we examined the above guidelines. Some of them are followed and implemented, but some are carefully revised to fit our application's needs. Moreover, trade-offs between the guidelines and our real-world implementations are observed and will be discussed in Sections 4 and 5.

Multi-touch capabilities enable simultaneous user interactions with a digital tabletop. They play an important part in supporting group collaborations. However, the implementation of multi-touch for a tabletop application is always restricted by the hardware on which the application is deployed. Today's most popular multi-touch technologies include the Microsoft Surface [12], the Diamond Touch [13], and the SMART Board [14]. They vary by the approach of capturing multi-touch, the ability to identify the users, and the maximum number of concurrent touches that can be recognized.

Edward Tse et al [15] investigate approaches to interact with a multi-user tabletop. They introduce a gesture (finger touch) and voice recognition engine for a GIS and Game application running on a diamond touch table, which is capable of identifying which user is interacting with the system. In our prototype, we use similar engines provided by the Microsoft's WPF framework, as well as SMART's SDK and evaluate their usability in agile planning meetings.

3. Tabletop AgilePlanner

Tabletop AgilePlanner utilizes Microsoft WPF (Windows Presentation Foundation) [16] and SMART [14] technologies to create a shared table surface for both collocated and distributed agile planning meetings. Our primary goal of designing the prototype

is to utilize digital tabletop technology in order to emulate collaborations of traditional pen & paper based planning meetings, which are observed a natural and effective way to conduct agile project planning. For this purpose, we created a shared tabletop workspace that displays electronic planning artifacts. Moreover, user interactions are carefully designed to emulate the behavior observed in traditional meetings.

Figure 2. AgilePlanner workspace

3.1. A shared planning meeting workspace

As shown in Figure 2, the AgilePlanner interface provides a planning meeting workspace that is shared across the network with other connected Tabletop AgilePlanners.

We abandoned using traditional WIMP (Window, Icon, Menu and Pointing device) interface to construct the workspace because 1. A WIMP interface often involves menus, buttons, and windows that cannot be analogous with pen-paper based meetings. 2. WIMP is typically used to design PC applications run on a small vertical monitor. Thus the UI elements, especially control elements, such as a menu bars, are often docked to a fixed position without the ability of rotation and translation. On a large horizontal table surface, the traditional menu bar will become unreachable if it is located on one side of the table and the user on the other side.

To overcome the usability problems of a WIMP interface, we create a simple, orientation-independent workspace that involves electronic story cards, iterations, and a control palette.

3.1.1 Electronic artifacts. Electronic story cards and iterations emulate paper artifacts that are used in traditional pen-paper based agile planning meetings. Since they have an identical appearance with the paper cards and contains all the items that are shown on the paper cards, a participant of pen-paper based meetings can easily transfer their understanding to the table based environment.

A translation and rotation (RNT) [17] algorithm is applied to the electronic cards. Participants in agile planning meetings are allowed to move and reorient the cards by using their fingers. This allows them to reserve cards for themselves and to improve the readability of the cards by orienting them towards the intended reader.

Although we try to avoid using "unnatural" WIMP elements such as buttons and menus, a small number of buttons are still required for some interactions. For example, "changing card color" needs meeting attendees to touch a target card first, and then click a color button. These buttons were placed on the *control palette*, an electronic artifact that can be moved, rotated, tossed and hidden on the workspace. The palette is more compatible with the table surface than traditional menu bars because it can be translated and reoriented, thus the "reachability" problem is solved.

Telepointers are an important artifact that represents remote interactions in a distributed environment. When a new Tabletop AgilePlanner client joins a distributed agile planning meeting, a "remote mouse" is created and displayed on every connected tabletop. The position of the "remote mouse" is synchronously updated with the movement of respective finger. Thus, a local collaborator will be able to see the finger actions of a remote participant. To identify the remote interactions, a telepointer is followed by a configurable text box with the remote user's initial.

Arm shadows [7] might be an alternative artifact to enhance the mix-presence collaborations. However, its usage is limited by hardware. Since we are using a SMART DViT for determining touch points, arm and hand shadows cannot be captured.

3.1.2. Display adaptability. The workspace of Tabletop AgilePlanner is adaptable to digital tabletops with different screen sizes. Today's digital tabletops are mostly research oriented and lack standardization of their basic parameters such as screen sizes and aspect ratios. The size differences can be ignored by a collocated agile planning meeting where only one tabletop is used. However, a distributed meeting that involves more than two tabletops requires a mapping between content displayed on different tables (and their respective coordinate systems). For example, Figure 3 demonstrates two remote tabletops connected by Tabletop AgilePlanner. Both of them are using GDI+ coordinate system. The tabletop in Calgary is only 1/4 as the size of the tabletop in Vancouver, 3/4 of the surface space on the tabletop in Vancouver is invisible to the collaborators in Calgary. As a result, an attendee in Vancouver can move a story card past the border of the Calgary tabletop. The participants in Calgary will

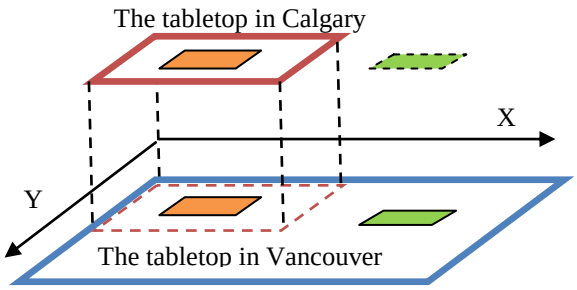

Figure 3. Tabletops with different screen sizes

not be able to see and understand the current state of the plan.

To solve the problem, we use a *zoom factor* for each Tabletop AgilePlanner. The zoom factor is a configurable positive value that determines the size and position of an artifact in a workspace. Using zoom factor 1, the workspace will show the original card size and location that is defined for a 1024 x 768 pixels display. When reducing/increasing the zoom factor, the card sizes and XY coordinates will be adapted to fit the size of a digital tabletop.

Zoom factor, to the best of our knowledge, is a novel approach of mapping unequal-sized digital tabletops. It works best when all tables connected have the same aspect ratio. However, if two or more tables have different aspect ratio, say 3:2 and 4:3, introducing a zoom factor can still cause the incomplete mapping between remote workspaces. We are now considering using scroll bar, a common UI component of PC applications. However, the usability of scroll bar requires further evaluation. Another possible solution is introducing a nonlinear projection to compress a large table to fit a small one [18]. However, the nonlinear projection relies on complex algorithms that will increase the difficulty of system development and might distort electronic artifacts' original appearance.

3.2. User interaction features

We designed two set of features for Tabletop AgilePlanner:

- "Natural" operations that emulate behavior observed in traditional pen-paper based meetings. They include moving, rotating, tossing, and editing (writing or erasing) cards.
- Operations never seen in traditional pen-paper meetings. They facilitate a meeting process (such as "create" and "delete" card) and overcome the shortcomings of tabletop surfaces. For example, "minimize cards" provides more usable space to teams that have a limited screen resolution.

While implementing these operations, we employ multiple interaction approaches supported by WPF or SMART Board.

Finger touch: Touch interaction supported by the tangible surface of SMART Board is a primary approach to emulate interactions in pen-paper based meetings. Tabletop AgilePlanner, participants can use their fingertips to touch and select story cards. A selected story card will be highlighted with a shining border indicating the focus of the current discussion. Meeting participants can also drag, rotate, and move story cards on the tabletop surface with their finger. To pass cards across a greater distance (i.e: a location outside arm's reach), we implemented "card tossing" – a simulation of throwing a card over a tabletop surface.

Handwriting input: In a traditional agile meeting, participants use pens to write task names, effort estimates and short task descriptions. Handwritten information is used broadly, although sometimes it is hard to read. On the tabletop AgilePlanner, we utilize the handwriting recognition engine that was originally used by tablet PCs to translate handwriting into electronic text. Thus, holding a stylus or using a fingertip, a meeting participant can write directly on the electronic story cards. The electronic ink strokes are erasable or can be saved for future planning meetings.

Gesture control: We use a set of gestures defined by the WPF to create new interactions such as "create story cards", "create iteration", "delete card" and "minimize card". Figure 4 lists some of the gestures we used. The gestures can be drawn on the table surface to trigger a related interaction. For example, by drawing a square (Figure 3(b)), a new iteration will be created and displayed at the position where the gesture is drawn. To delete a card, a "ScratchOut" gesture should be drawn over the targeted cards boundaries.

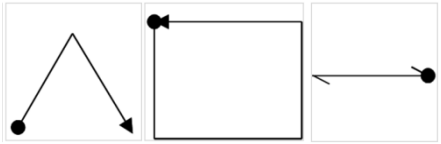

Figure 4. Gestures for Tabletop AgilePlanner

Voice Control: We employ the voice engine from Microsoft's WPF and defined some simple voice commands such as "create story card", "delete card" and "highlight". Meeting attendees can speak in to a microphone, and their voice will be converted to respective interactions.

Table 1 summarizes basic features implemented by the Tabletop AgilePlanner and compares them with traditional pen&paper based agile planning meeting.

Table 1. Features of Tabletop AgilePlanner

Feature set	Tabletop AgilePlanner	Pen&Paper based planning
Gesture Support	create/delete story card/iteration	fetch/trash card
	undo/redo	N/A
	minimize card	fold card
Finger Touch	resize card	N/A
	highlight card	point to/pick up card
	change color	N/A
	save meeting scenario	take a picture for table surface
Handwriting	edit card with keyboard or stylus or finger tip	write with a pen
Voice Re-cognition	use voice to operate cards	N/A

3.3. Implementation

Tabletop AgilePlanner is implemented using a SMART Board on a table with a 183cm x 122cm, 5120 x 2048 pixels screen (see Figure 5). The screen consists of eight separated LCDs that form a grid on the tabletop surface. The SMART Board employs DViT technology to detect touch based interactions. In contrast to other touch based table system, DViT does not need a sensitive surface or special pointing device like a stylus. With four cameras placed on each corner of a table surface, a maximum of 2 touches can be captured at any given time.

Since everything touching the SMART Board screen consumes a touch point, users cannot put their elbows, coffee mugs or pads on the tabletop directly. To solve the problem, we design a thick, wooden boarder to allow users to bring their personal belongings to the table surface.

Figure 5. The hardware platform

Tabletop AgilePlanner is a client-server application. The client is developed with WPF which provides a sound platform that supports tabletop applications. UI components of WPF can be easily transformed by size, position, and angularity. This facilitates the implementation of the *zoom factor* feature. Handwriting, gesture and voice recognition engines are available in WPF's environment. To support a distributed agile planning meeting, an AgilePlanner client not only captures local user interactions, but also receives and visualizes remote interactions, such as synchronizing telepointers with remote finger movements. Clients send changes to the AgilePlanner server which, in turn, distributes them to all connected clients.

AgilePlanner Server has been inherited from our desktop version of AgilePlanner [19].

4. Evaluation

We evaluated the usability of Tabletop AgilePlanner as well as ascertaining the impact of digital tabletops on agile planning meetings. Two key questions will be answered:

- Does Tabletop AgilePlanner facilitate agile planning meetings?
- Does Tabletop AgilePlanner maintain/change the natural behavior observed in traditional pen&paper based agile planning meetings?

4.1. Controlled study

We conducted a task-centered walkthrough to evaluate the usability of basic interactions with Tabletop AgilePlanner. The study was held in a lab environment with nine test participants who are master students. The participants are all familiar with agile concepts. Most of them have previous experience with using tangible device such as tablet PC, but only 2 of them had used a tabletop before.

The nine participants used Tabletop AgilePlanner deployed on our SMART table to complete 15 pre-defined tasks. The tasks covered collocated and distributed scenarios. They represented typical individual interaction (such as create story card) and group collaboration (such as one person passing a card to the participant opposite to him/her) in agile planning meetings.

During the evaluation, we observe the subjects' interactions and noted their reactions, comments, and behavior. Having completed all of the tasks, an informal interview was conducted with the participants, particularly those who had difficulties completing some

of the tasks. They were asked to comment on our system and explain what hindered their performance. A questionnaire form was also provided.

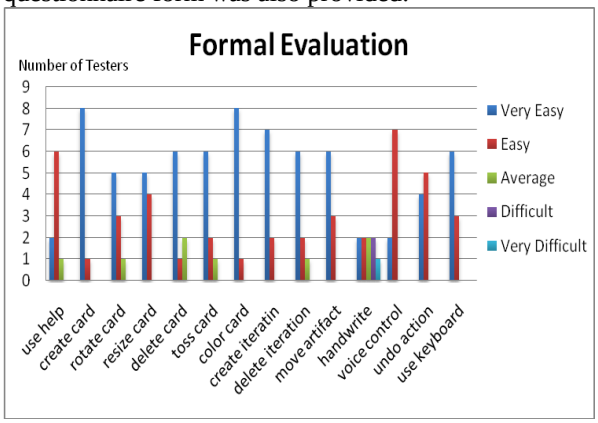

Figure 6. Result of likert-scale survey

Our survey indicated that most participants felt Tabletop AgilePlanner was "easy" or "very easy" to use (see Figure 6). Some of them comment that using digital tabletops to complete the tasks was "natural" or "interesting". Moreover, we found that participants would always rotate newly received cards so that they are oriented towards themselves. This might be a result of improved readability of this orientation or it might indicate an awareness of a personal territory [20].

Test participants often commented on the gestures. The participants realized the benefits of using their finger gestures to complete tasks. They considered using finger gestures to be more convenient than looking for buttons on "such a big table". However, some participants couldn't remember the meanings of all the gestures and as a result their gesture actions got unexpected results.

Voice control was considered a "cool" but "not so useful" function. A primary reason was that the voice recognition engine was unreliable. We observed that some voice commands, especially those from participants with accents, were not recognized. Instead of blaming the technology, these problems embarrassed some participants. Moreover, some subjects felt using a microphone to control the tabletop was not as intuitive as using their fingers.[1]

Some usability problems with handwriting input were observed. Our questionnaire survey shows that many users did not like to use their fingertips or styluses to write story cards, even though handwriting is a normal behavior in traditional planning meetings. Further interviews uncovered the reasons: The finger tips of some users are thick (compared to a mouse pointer) so it was difficult to draw narrow ink strokes accurately. Moreover, when writing with their fingertips or styluses, users are not able to put their fists or hands on the table surface because a fist (hand) touch is recognized as several touch points by our tabletop which allows only two concurrent touches. Holding a hand as required is tiring, unnatural, and in our opinion, the main reason why study participants did not like to use handwriting on the digital table.

To test the usability of distributed collaborations, we connected our SMART Board (5120 x 2048 pixels) with a touch-screen computer which had a resolution of 1440 x 900 pixels. Two participants were required to complete some collaborative tasks by using two tangible devices placed on the different sites. Since our tasks do not require oral communications, other communication tools like conference phones are not involved in the evaluation.

Our evaluation indicated, by setting up a proper zoom value, a shared, adaptable tabletop workspace can be established on two displays. However, some subjects who used the touch-screen computer commented that the story cards seemed too small on their workspace and were hard to read. The problem was caused by the differences in screen resolution: a trade-off between showing the complete workspace and keeping a large card size had to be made. Our current implementation shows everything from the larger display and scales it down to display on the smaller screen. When the differences become too large, text on the smaller screen becomes hard to read. An alternative solution would be to introduce horizontal and vertical scroll bars for the workspace. We hope these scroll bars combined with a proper zoom factor can create a complete and readable workspace for distributed agile collaborators.

Telepointers got positive feedback. In some remote task scenarios, subjects could clearly figure out who was pointing to which card by watching a remote mouse moving across the screen. Some subjects suggested it might be more interesting to use a cartoon or photograph of a remote user than a traditional mouse icon to show a telepointer. The problem is that our current hardware does not allow us to distinguish between different users on the same site. Thus, we can't associate the picture of a specific user with a remote mouse pointer.

4.2. Team observation

1 We agree: when we use Tabletop AgilePlanner for our own planning meetings, we never use voice control because the headset required for accurate recognition interferes with discussions during the planning meeting.

To understand how Tabletop AgilePlanner affects real agile practices, and how natural behaviors is kept and changed, we observed its use by an eight-member collocated agile team (from our research group) in real planning meetings. We observed 8 meetings based on pen&paper or digital tabletop. We found similar patterns in both types of meetings, such as passing (moving or tossing) cards among each other and sorting cards to determine their priorities. We also found new operations provided by the Tabletop AgilePlanner (such as minimize cards) were frequently used. Moreover, as a new interaction approach, gestures were popular among the participants.

However, the finger and stylus input were rarely used for text input. Keyboard becomes a popular alternation. Some developers mention that text input via the keyboard is faster, more accurate and readable. Moreover, they express that using keyboard is as natural to them as using pens, although sometimes they have to get the keyboard from another attendee.

We conducted interviews with the agile team and most of the interviewees expressed a preference to tabletop agile planning meetings. The subjects also found that using a large horizontal display better supports their planning meetings than using a projected PC screen. However, they feel the current amount of simultaneous touch points are far from enough: participants interfered with others interactions on the table.

4.3. Limitation

The evaluation in this paper may be moderately biased due to the selection of participants. Therefore the above results are limited in scope. In the controlled study, most participants will not have used a digital tabletop before. Their positive perceptions might be from their excitement to be able to use innovative tabletop technology. Therefore, a long-term study will be conducted to solidify the conclusions.

Due to the lack of commercial available digital tabletops and their costs, we have not evaluated the tool with an industrial distributed agile team. However, we expect that with the rapid development of tabletop technology, an increasing number of commercial digital tabletops will become available to agile teams in the near future. We believe that we will then be able to organize a field study to evaluate the real use of digital tabletops in a distributed agile team.

5. Discussion

In this section, we list some experiences, issues and trade-offs found from the design and implementation of Tabletop AgilePlanner.

Input mechanism. We found using a keyboard is more applicable than using handwriting input, although the tabletop is tangible and handwriting recognizable**.** Most participants expressed their interest in using finger or stylus to write on story cards. However, in a real practice, they used keyboards. Our evaluation indicated three factors that affect their preferences. First, it is not comfortable to write directly on our table. The participants cannot put fists or hands onto the tabletop surface to stabilize their stylus. Second, they are skeptical that their handwriting can be recognized. Compared to typed texts, handwriting is often harder to read. Third, as developers they use keyboards as naturally as pens. One subject comments that *"I always consider the tabletop a computer with a big, horizontal screen, so looking for a keyboard is always my first choice".*

The use of gestures. Using finger gestures is more effective than using traditional mouse actions since a finger gesture can simultaneously represent the meaning and the position of a gesture. A typical example is "creating card". In the desktop AgilePlanner [19] which was designed as a PC application, "creating a card" often involves finding a card icon (story card or iteration) on a side menu, moving mouse to the icon and dragging it to the targeted position. As an alternative, using finger gestures will simplify the operation: meeting attendees can draw a gesture (see Figure 3) on the table surface and a related card will be created at that position. However, there are some shortcomings when using gestures. First, users need to learn and remember gestures. Second, gestures can represent a limited number of artifacts or commands. A large set of gestures will cause additional ambiguity for the users and increase the difficulty of remembering each of them.

Remote embodiments. Tuddenham and Robinson [7] argue that the telepointer is a naive remote embodiment with negative effects on collaborations. They prefer the virtual arm for the distributed tabletop. However, for agile practice, telepointers are sufficient.

According to our observations, most agile planning time is spent on discussions, rather than operating the electronic artifacts. An agile planning meeting is essentially a team discussion and the time spent on interacting with the tool is minimal. Respectively, only a small set of touch interactions are required during each planning meeting. Moreover, our evaluation indicates that the most important information for distributed agile collaborations is the position of a

touch point and an identification that represents the touch point. Both of the elements are provided by the telepointers of Tabletop AgilePlanner. Pursuing advanced embodiments does probably not bring any extra benefits during distributed agile planning meetings, but increases the additional costs and hardware dependency.

Inconsistent remote workspaces. A distributed agile team often owns two or more displays with different screen resolutions. Setting up an identical, complete, and readable workspace becomes a problem. In Section 3, we introduced a zoom factor to offset the side effects of resolution differences. However, it may not be an optimal approach, especially for two tabletops with different aspect ratios. We are now considering the use of a scroll bar or introducing nonlinear projection. However, the usability of either solution requires careful evaluation.

6. Conclusion

We believe that the development of Tabletop AgilePlanner is a valuable exploration to combine tabletop hardware and research with agile planning. This paper contributes to the current literature in three different ways. First, we introduce the design of a tabletop based agile planning tool, and discuss the usage scenarios as well as user interactions with Tabletop AgilePlanner. Second, we evaluated our tool. Based on the evaluations, we reveal improvement opportunities and usability problems for developers of agile planning tools. Third, we point out some design trade-offs for agile and tabletop domain experts. We believe that the exposure of these trade-offs can trigger new thinking regarding the development of team-oriented tabletop based applications.

Future work will involve extending usability studies of Tabletop AgilePlanner. New interactions will be integrated according to the needs of agile developers.

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