Tangible Interaction Techniques To Support Asynchronous Collaboration

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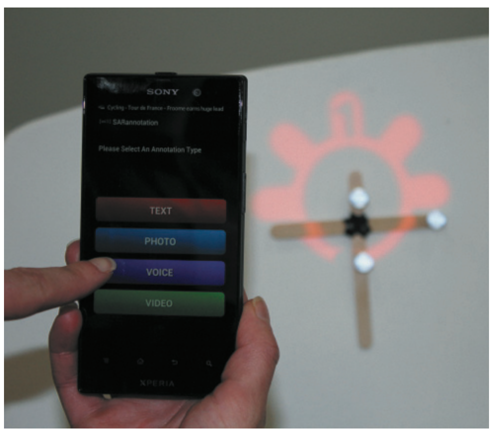

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Abstract

Industrial uses of Augmented Reality (AR) are growing, however their uses are consistently fashioned with an emphasis on consumption, delivering additional information to the worker to assist them in the completion of their job. A promising alternative is to allow user data creation during the actual process by the worker performing their duties. This not only allows spatially located annotations to be produced, it also allows an AR scene to be developed in-situ and in real-time. Tangible markers offer a physical interface while also creating physical containers to allow for fluent interactions. This form factor allows both attached and detached annotations, whilst allowing the creation of an AR scene during the process. This annotated scene will allow asynchronous collaboration to be conducted between multiple stakeholders, both locally and remotely. In this paper we discuss our reasoning behind such an approach, and present the current work on our prototype created to test and validate our proposition.

Author Keywords

Augmented Reality; Asynchronous Collaboration; Spatial Annotations; Tangible Interaction

ACM Classification Keywords

H.5.3 [Information interfaces and presentation (e.g., HCI)]:

Group and Organization Interfaces–Asynchronous interaction–Computer-supported cooperative work; I.3.6 [Computer Graphics]: Methodology and Techniques–Interaction Techniques

Introduction

Annotations within AR have been used and demonstrated successfully using various interaction and viewing mechanisms to achieve an improvement in industrial processes. Local annotations can be attached, using virtual display methods, or detached, using sensors and external displays [6]. Typically, locational based annotations are more relevant to a larger area, i.e. a tourist guide, than to a specific point on a piece of machinery which an engineer may be more interested with. Synchronous approaches to Computer Supported Collaborative Work (CSCW) have been investigated using procedural guidance [2, 7] and remote guidance [1, 5] however these approaches rely on pre-programmed or repetitive instructions. As a comparison, asynchronous techniques allow independent interaction with the system. This results in a growing knowledge base, while collaborators interact back and forth. It also allows for in-situ responses during the work process, offering a production value to AR.

To achieve this collaborative interaction, we propose the use of Spatial Augmented Reality (SAR) [9] in conjunction with mobile AR [4] and tangible markers. SAR removes the intrusive displays required to view attached annotations, while the tangible markers offer a locational and physical benefit. SAR also requires a virtual model of the scene to allow for correctly registered augmentations. This underlying system allows a virtual scene to be created during annotating, allowing for off-location experiences. The tangible nature of the markers will also allow spatial registration, physical manipulation and process recognition, helping users better understand the problem space. With the combination of a mobile platform, users are capable of viewing a birds-eye view of the virtual SAR scene through a touch enabled display. This form factor also allows an intuitive interaction for the addition of annotations. The mobile interface can also serve as a back-up visualisation tool, if SAR were to become unavailable.

Maintenance offers a suitable scenario to demonstrate the strengths of our approach. While undertaking the regular maintenance of an industrial machine, the worker notices an issue with its oil pressure. If we assume that the worker is out of their depth, a remote expert may be called in to provide guidance. Rather than using general communication channels to portray the current state of affairs to the expert, the annotated scene can be sent to allow them to have a better understanding of the problem space and propose the next action to take. The tangible markers provide locational context to the positions of tests offering a greater understanding to the expert. They also offer grounded points of relation, which the expert can use to communicate back to the worker. The worker could however bring up the historical data associated with the particular part where the pressure is dropping and investigate the previously attached annotations. Through visual recognition, an error may be sighted with the location of the tests currently being undertaken, or a better understanding of the problem area may be achieved.

Related Work

Collaboration can exist within any of the four space-time configurations [10]. AR instructional guidance has been demonstrated as providing an improvement to work processes [2, 7]. Instructions are created externally and then virtually augmented across the user's workspace to provide direction. Instead of requiring a head-worn or hand-held device to visualise the workspace through, projectors can be used to augment instructions directly onto the workspace [5, 9], removing the need to use the intrusive displays.

Annotations can exist with specific spatial reasoning [2, 7] or within a 2D plane [1, 5, 4]. The later variety refer to a remote guidance problem, where synchronous instructions are generated by a remote expert, who instructs a local user by annotating across a transmitted video feed. These annotations are attached, however carry no specific spatial registration to the local user's workspace [6].

What are the Benefits?

We foresee four main benefits of utilising an asynchronous approach to CSCW within an AR setting: flexible contribution times, knowledge retention, increased problem space understanding and awareness, and combining with existing processes.

Asynchronous collaboration's strength over its synchronous counterparts results from its ability to allow collaboration to occur at flexible times. This design feature becomes apparent when collaboration is required between multiple stakeholders on opposite sides of the world. Rather than organising a time to allow a synchronous discussion, each member can respond to questions and add further notes at their own pace, before the same scenario is conducted a few hours later on the opposite side of the world. This freedom to express without time constraints can result in a more informative discussion about the subject matter.

As highlighted in [10], email and post-it notes serve as two communication mediums that support knowledge retention. Post-it notes offer additional context compared to email, as their location can offer supplementary spatial cues to help assist in understanding the content within. Our research proposal offers the perspective of associating a technological presence to a post-it note. In the same context, our tangible markers will allow spatial cues to be associated with the contained content, offering a more informative outlook to understand the problem space. Tangible markers used to locate and attach annotations can help assist and prompt an operator's memory. While using multiple markers, users can create associations between one point and another. Knowledge retention also allows for an in-situ creation of AR driven instructions. While both video samples [8], and computer generated [7] aids have been used to create instruction sets, our tangible input mechanisms will allow for contextually attached instructions to be left within a real physical workspace simultaneously while a user completes their work, creating a virtual workspace available for external response at a later time using SAR's inherent infrastructure [9].

This functionality leads into remote guidance, where external experts help assist local workers through dictating instructions [1, 4, 5]. For an expert to fully understand the problem space, a precursor to guidance is needed where an understanding of the current state of affairs is achieved. Instead of using contextually unaware communication channels such as email or phone, a virtual AR scene can be transferred to the expert, where they can investigate and confirm the local workers process. This investigation and response, through further annotations, can occur at independent times, offering a more complete opportunity to understand and formulate a proposal.

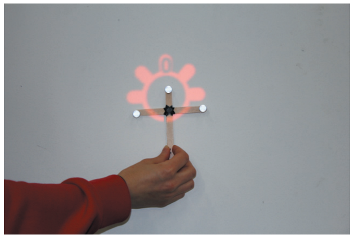

Figure 1: Placing an annotation

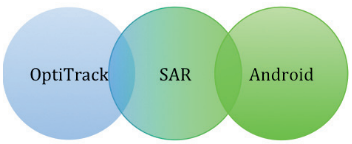

Figure 2: Prototype composition

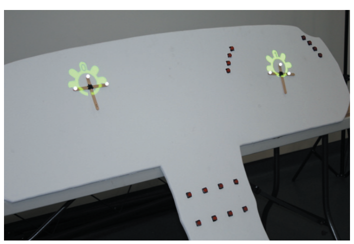

Figure 3: An annotated object

Research Question

Our questions embody the investigation of improved context, and the repercussions of having this available to a user during the completion of a work process. We are interested in understanding if tangible interaction offers additional memory cues, allowing operators to formulate the problem they are facing in a superior fashion (R1).

A key benefit of using a tangible interface to allow annotating is the removal of additional viewing hardware for initial detection. Users can scan the worksite with their own eyes, and recognise areas where additional content is located. A physical marker also carries a definitive spatial location where it exists. Does this definitive spatial cue assist in the understanding of the problem (R2)? We are interested in investigating the results in both the physical workspace (R2a) and virtual workspace (R2b). Likewise, this spatial context can have rich media associated to that particular point in space. Through the contextual annotation of rich media, does the operator have a higher understanding of the problem at hand (R3)? Similarly, we are interested in comparing the results in both the physical (R3a) and virtual (R3b) workspaces.

Through adding an additional interface for the worker to negotiate, we are intrigued to identify if this poses any further complications for a worker completing their task (R4). For example, do they feel it a hindrance to need to apply a physical object to the location they wish to annotate? As a comparison to a virtually located annotation, we are interested to see how comparable manipulation can be when information is required to be moved (R5).

Annotation Prototype

The prototype is currently comprised of three main hardware components: an Android device (Sony Xperia Ion), a 6DOF tracking system (OptiTrack) and roof mounted projectors (NEC NP510WG). The software for the prototype is developed using C++ and OpenGL, running on Ubuntu across the WCL SAR visualisation studio framework. The OptiTrack system combines 6 x Flex:V100R2 cameras to provide an area to perform 6DOF tracking of our interface, while projectors are used to augment the area (Figure 4). The Android API allows for textual, photographic, video, and vocal annotations to be attached to the tangible markers.

The prototype is divided into two sub-modules (Figure 2). OptiTrack cameras provide continuous 6DOF tracking of our tangible markers, providing the system with their current position and orientation data.

Our prototype demonstrates the functionality presented to the worker, to provide analytical support during workflows. Each tangible marker can be placed onto the model, and an annotation registered to its location (Figure 3). Through the Android application, the user can decide which type of annotation to attach (see first page), before completing the action, taking a photo or video or typing up notes (Figure 5).

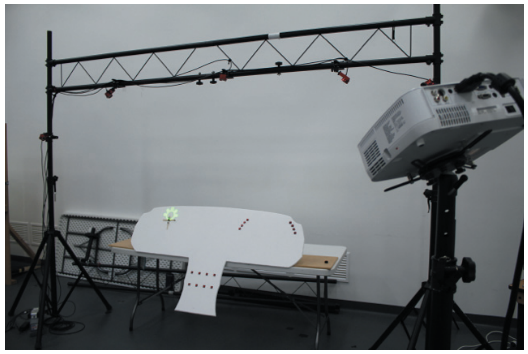

Figure 4: The lab set-up.

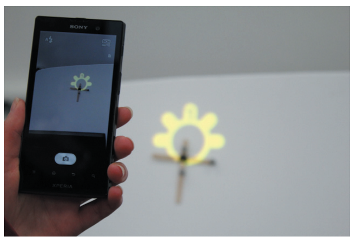

Figure 5: Photographic Input

To add an annotation, a tangible marker is placed at the location which is of interest (Figure 1), which prompts for further input through the mobile platform. To modify and delete an annotation, a tangible marker is lifted from its point of interest. This manipulation then prompts the user to either save, and create a virtually stored annotation, delete the content, or perform modification. As each tangible marker is placed, an ID is associated with the annotation. This then allows an ordering of notes, and to offer the opportunity for procedural steps to be entered into the system (Figure 6).

Figure 6: A complete annotation

Although the markers operate as a container for virtual annotations, due to their tangible nature, they also offer the benefit of being used as a reminder for the operator. An operator may be finding the route of a pipe across a machine, a tangible marker may be used to mark one end, while further work is undertaken at the other end. During a change of shift, the marker remains to direct new workers to understand the current state of affairs, and continue with the work. We foresee the combination of markers to be further utilised to allow relationships to be created between points of interest.

We also wanted to offer a combination of visualisation methods for use by the local worker. By using projectors, workers hands are free to continue their work while they can experience the visual triggers attached to the tangible markers. Projected annotations provide a simple aid of the type of annotation attached. When they are removed from the markers, and attached virtually to the object, they continue to present a reminder to the worker of the presence of additional information. The virtual scene can also be replicated through the mobile handset. Instead of using the mobile as a 'magic lens' [6], a virtual representation of the workspace can be displayed on the mobile screen.

Discussion & Future Work

Our work is in a prototyping phase, with a need to properly evaluate the usability of such an approach. The benefits of our design are warrantable, however a full user study is needed to conduct the benefits of using tangible markers to aid in the understanding, and analytical aspects of improving a work process.

Before usability tests are conducted to evaluate the effectiveness of our user interface, we first need to ascertain the underlying benefits of our collaborative technique. This can be achieved by analysing the benefits of understanding a scenario through additional markers, used as a trigger to remind the user of a series of steps. A comparison in the ability to create the steps in a procedural task, through our annotation techniques could be compared to a paper task. The created tasks could then be evaluated by a third party to uncover the benefits of our context driven annotation techniques.

To evaluate our interaction techniques, the benefits of a physical interface are needing to be compared to their virtual counterparts. A comparative evaluation can be performed between physical and virtual annotations during creation, modification, and transformation. Quantitative tests can be conducted to measure the speed, accuracy and search times to complete prescribed tasks.

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