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Novel Human Machine Interaction with Sticky Notes for Industrial Production

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***Abstract*— In this paper we present a 3D documentation system which utilizes new human machine interaction concepts on the example of virtual sticky notes. Using different tracking techniques the virtual notes can be attached to a physical object and are displayed on a tablet in an Augmented Reality way. The main intention is to strengthen the interplay between construction and production of industrial machines as the virtual notes are synchronized with a production lifecycle management system.**

I. PROBLEM DESCRIPTION

An essential part of machine manufacturing is the interplay between construction and production. Often this connection leaks information in both ways: the construction team changes details in the last minute, while in production things are mounted in a different order or way as it was intended. Since in the end both sides have to synchronize their knowledge this results mainly in a mass of notes often stuck on the machine or even worse written on the machine itself. This industrial spotlight paper presents a novel development integrating latest technologies to manage position based notes digitally in an Augmented Reality based way.

II. STATE-OF-THE-ART

Although in media one can see photos of tablets showing Augmented Reality (AR) overlays of shop floors, industrial grade AR documentation systems are rare. To our knowledge the most similar system available to our proposition is Docufy [1]. It is an AR interface to a dedicated content management system and used to display technical content like manuals in a read-only way. The mapping of the data to 3D is managed via a manual registration step of interest points originating from a priori known CAD data. When the tablet is moving, the interest points are tracked and the 3D data adapts to the new viewpoint.

III. PROPOSED SYSTEM

In this paper we propose a system which enables a user to view, edit and add virtual sticky notes to a machine during assembling by using Augmented Reality techniques. The notes are position dependent and synchronized with the 3D database of a production lifecycle management (PLM) system. Since the construction team mainly works with the PLM system, they immediately have access to the information and may modify existing or add new notes directly.

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A. Tracking System

For the tracking we pursue a multi-modality strategy, which utilizes a combination of

- a commercially available infrastructure-based tracking system,
- fiducial Augmented Reality markers,
- and a visual real-time tracking system.

The infrastructure-based tracking system is the main source of 6 degree-of-freedom (DOF) data for the system. See Figure 1 for a tablet enhanced with a tracking system receiver. The two major extensions to the state-of-the-art

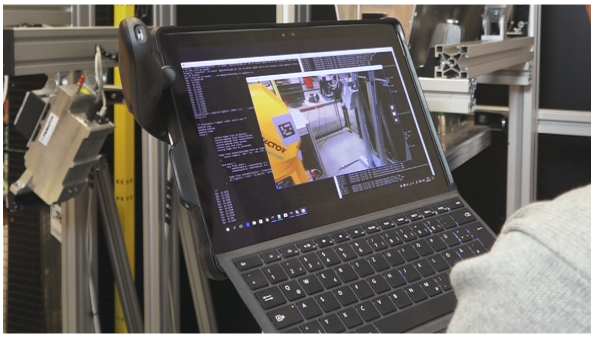

Fig. 1. Tablet with attached tracking system receiver on the left side. This enables a 6 degree-of-freedom positioning in space.

concern the tracking part as well as the way a user can interact with the system.

The initial registration is done with an AR marker system based on the work of Garrido-Jurado et al. [2]. Fiducial markers are preferred to feature based approaches as the presence of stable features on industrial objects cannot be guaranteed. After that the tracking data is transformed to the coordinate system of the machine's CAD model which is provided by the PLM software. This allows the attachment of notes to positions in the CAD data.

A special approach is required for movable parts of the machine, like panels. When mounted to the machine, their relative positions to the base CAD data can be determined using attached AR markers.

An additional feature was built in to handle unmounted sub-assemblies. They can be annotated like any other machine parts, however they have to be pre-identified in a manual step. This is the input of a real-time tracker which is an extension of Akkaladevi et al. [3].

When a user likes to add a new note to the machine he/she has two possibilities to define the position: either the desired position is touched with the measuring tip mounted on the backside of the tablet or an additional AR marker is put on the desired position, see Figure 2. The additional marker can be removed after the system took over its position. While the measuring tip might be the more intuitive way to define a position, AR markers have an advantage: they can be combined with note-templates, e.g. different markers for different users or different types of notes.

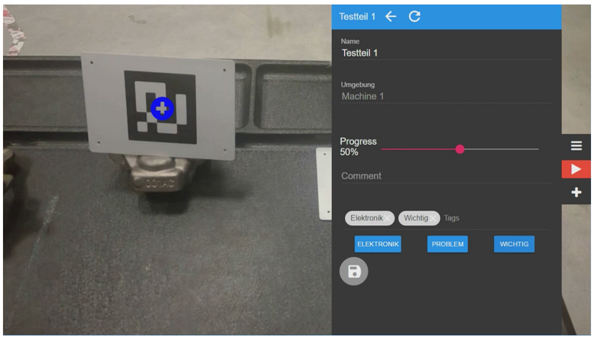

Fig. 2. Screenshot of position input via an additional marker in the image. The position of the marker defines the position of the new sticky note. The pane on the right shows pre-defined tags connected with the marker.

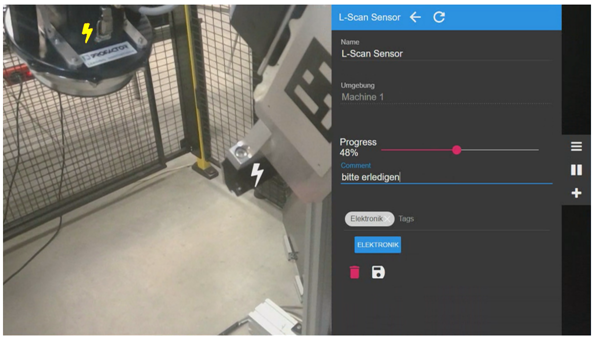

Fig. 3. Screenshot with two sticky notes in the image (flash icons on the left). The top left note is selected and the pane on the right displays the according information.

B. Human Machine Interaction

The base of the human machine interaction is a live view of the tablet's camera in which the sticky notes are overlaid in an Augmented Reality fashion. When touching a note, a form with additional information pops up, see Figure 3. From a technologically viewpoint this is a HTML overlay, reflecting the client-server based architecture of the software.

Beside the standard information for a sticky note like name, type, and description an additional tagging system has been implemented for a flat hierarchy of the notes. To each note one ore more pre-defined tags can be assigned, which allow an easy to use filtering, e.g.: showing only electronic related notes in the view. Examples of the tags can also be seen in Figure 2 and 3 on the bottom right.

Furthermore the system supports different user roles, which differ in the amount of information they can edit and/or which sticky notes they can see.

IV. TECHNICAL EVALUATION

The system is currently in an evaluation phase. Tests regarding positioning showed up accuracies of ± 0.5cm in a volume of 5m$\times$5m$\times$5m.

The used hardware is a standard Microsoft surface tablet with the internal camera set to a resolution of 1280×720px and a maximum achievable frame rate of 25fps of the overlay. However the limiting factor for the frame rate is the tablet camera itself. With an external industrial camera frame rates up to 100fps have been achieved.

For the registration step and the moveable parts also the marker size and camera-marker-distance have been evaluated: for a reasonable marker size of 7cm the largest distance to the marker is 2m. With higher distances the detection and therefore the visualization becomes in-stable.

V. CONCLUSION AND FUTURE WORK

In this paper we presented an industrial grade AR based documentation system which extends the current state-of-the-art by integrating additional tracking modalities and furthermore allows the user to edit the information in an intuitive way. The proposed system is currently on a technology readiness level of 7. The next steps are extensive field tests. Although the system can be used stand-alone, the ideal synergy is together with a PLM system. Currently the import/export functions support only one such system, however this will be extended in future.

Furthermore of vital interest is the evaluation of time savings gained by using our system. For this a detailed study will be set up together with industrial partners.

From an application point of view a possible extension could be the replacement of the PLM input with a Virtual Reality (VR) system. This would allow one user to add information on a model in VR which is then immediately shown to a different user on the real object. This could be the base for numerous multi-user scenarios e.g. the usage as remote maintenance system. The advantage over a traditional 2D camera assisted remote maintenance system would be the exact 3D positioning of the information on the object of interest.

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