The need for accuracy statements in industrial Augmented Reality applications

Katharina Pentenrieder * Peter Meier

metaio GmbH

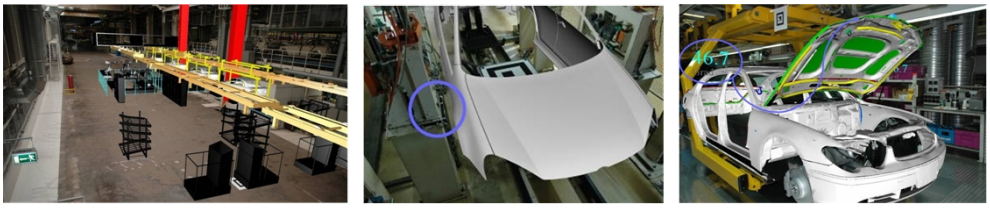

Figure 1: Industrial AR: (a) Change management in factory planning, (b) Interfering edge analysis, (c) Head space in assembly

ABSTRACT

In industrial applications Augmented Reality (AR) is today an established technology for supporting industrial applications in areas like design, planning, training and maintenance. Growing importance of measurements in AR environment changes requirements for AR applications giving more importance to accuracy and stability than to mobility and real-time demands.
This position statement emphasizes the need for accuracy statements in industrial AR applications and thus the necessity of hardware and software providing the required accuracy on the one hand and the ability to state this accuracy on the other hand. We present Roivis^{TM} as an AR application which offers this functionality and discuss several applications for the tool in visualization and measuring.

1 INTRODUCTION

1.1 Industrial applications for AR

In the past years Augmented Reality (AR) has a carved out its place as a valuable technology for supporting industrial applications in areas like design, planning, training and maintenance. Research projects like ARVIKA and ARTESAS have worked on applications for AR in industrial development, construction and maintenance [2], [3]. In [1] Doil et al. discuss a prototypical AR system for supporting planning tasks.
Most of these systems use mobile AR systems based on robust tracking and visualization via video-see-through or optical see-through head-mounted displays (HMDs). Overall one can state that for long-term success in industrial AR both tracking and visualization require further improvements. And for current applications it becomes crucial to know how accurate the tracking actually is.

Another reason for the critical role of accuracy in industrial AR scenarios is given by measuring tasks. Within the AR-Plan project [1] measuring is introduced as one possible tasks within the AR-based planning system. This first implementation supports simple distance and position measurements for real and virtual objects. Through the growing importance of AR in industrial design and planning environments several new applications for measuring tasks have resulted, especially in the area of change management and collision detection and interfering edge analysis (see figure 1(b)):
In factory planning real objects can be compared to original virtual construction plans and differences can be evaluated using measurement techniques. Reconstruction of factory buildings or manufacturing segments require analysis of possible collision points or bottlenecks throughout the production line. Finally modification or new designs of products need to be checked for collision in existing factories.
All these tasks require some kind of measuring possibilities for accurate distance measurement or interfering edge and collision detection analysis. In order to rate the measured values, information on the accuracy of the underlying system is necessary.

In an AR system this accuracy can be weighted as the difference of the actual position of a virtual model in the environment and the position where the model ought to be for perfect overlay (see figure 2).

1.2 Measurements and Accuracy

According to an ISO standard [4] measurements are always subject to errors and therefore always only estimated values. Even if known static errors are removed, noise remains which cannot be compensated.
Hence measurement statements are incomplete without a corresponding accuracy statement. This accuracy is a value indicating the distribution, the variable which is measured can reasonably have. The value can be a standard deviation or an interval for a defined level of confidence.

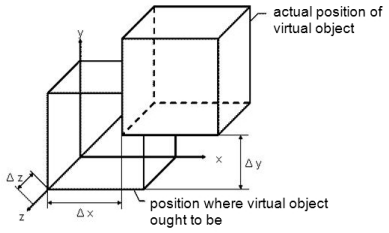

Figure 2: Difference: actual and ought-to position of virtual models

*e-mail: katharina.pentenrieder@metaio.com

For measurements in AR applications we are therefore interested in additional accuracy statements to gain a complete measurement information according to the ISO standard.
This implicates on the one hand the need for AR systems which provide accuracy information for all steps in the tracking chain. On the other hand, given these accuracy values, systems are wanted, which offer a very high amount of accuracy to achieve optimal results.

2 Tracking Chain - Application to the AR scenario

2.1 Influence factors in the tracking chain

Up to the creation of a measurement information at a certain 3D point in the AR environment a number of parameters are involved which influence the accuracy of the resulting value. Figure 3 depicts this process for a 3D point measurement task in metaio's AR application Roivis^{TM}.

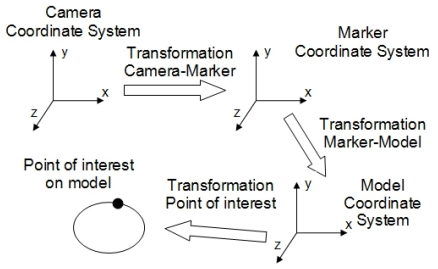

Figure 3: Accuracy chain for 3D measuring

Tracking The most important influence factor is the tracking result. For metaio's square-marker tracking system the 6D pose result is generated via corner extraction non-linear pose estimation. The results are depending on image quality, illumination and last but not least on the size and orientation of the marker in the image.

Camera calibration Another important factor is given by the camera calibration meaning the intrinsic parameters of the camera. Again image quality and underlying algorithms can lead to highly variable calibration results for one single camera.

Additional offset parameters Finally measurements are usually taken at positions which are given relative to the marker or even relative to coordinate systems which are defined based on the marker coordinate system. Hence additional influence exists through the accuracy with which the marker has been placed or the determination of the coordinate system offsets.

2.2 Conclusions

Based on the influence factors from the previous section a number of conclusions can be drawn which indicate requirements for measuring and accuracy in AR applications.

Precise and stable tracking with accuracy information The largest influence on the measurement result is held by the tracking accuracy. As optical tracking is dependent on a lot of factors it is crucial to identify tracking environments and hardware with optimal conditions for precise and stable results.
On the one hand accuracy information is needed for the tracking system, to be able to define a confidence interval for the pose estimate. Accuracy statements for representative tracking scenarios must be provided. This requires the concrete evaluation of a tracking system according to relevant influence parameters.
On the other hand, the tracking itself should be as precise and stable as possible. Hence algorithms must be developed which elicit the best-possible results from given input and additionally the input, the images, must provide optimal information for the feature extraction: High quality, high resolution and few to no distortion through good illumination and good cameras and a large view of the marker with many pixels through focus on the relevant areas.

Good quality cameras with stable intrinsic parameters For optimal image input and for stable intrinsic parameters high-quality cameras are necessary where focal length and distortion parameters can be calibrated with small errors.
Again additional accuracy information must be available for the intrinsic parameters. Little variance out of several calibrations indicates stable mean values and good quality of the calibration.

2.3 Roivis^{TM} - Accuracy for AR applications

As solution for accurate measurement tasks in AR based planning environments metaio provides the tool Roivis^{TM}. Roivis^{TM} offers general functionality for AR through marker tracking based augmentation and 6D manipulation of VRML models. Additionally several measurement functionalities are included like collision detection, distance measurement and accuracy measurement. The last functionality is only available for high-resolution still images with a special accuracy-based camera calibration to ensure optimal quality and certainty for the calculation result. The computation combines tracking values, intrinsic camera parameters and optional additional offset parameters for the 3D position measurement. Additionally accuracy information from a tracking database and the special camera calibration are combined with optional offset accuracy information to form a standard deviation information for the specific 3D point.

3 Applications

The measurement functionalities of Roivis^{TM} have already been applied successfully in many industrial scenarios.

At Volkswagen interfering edge analysis was done to evaluate new models of car bodies at bottleneck areas in existing production sites. Using AR the virtual models were superimposed on high-resolution images of the critical areas in the factory (see figure 1(b)). Collision detection and measurement tools were applied for analysis.

An example for change management in factory planning at Siemens is shown in figure 1(a). Here virtual planning data is verified using AR and discrepancies are evaluated using measuring techniques.

Head space analysis in car assembly at BMW is presented in image 1(c). Again AR measurement tools are applied to identify the possible cover angle.

For all these applications it is crucial to know the accuracy of the measured values for a complete evaluation of the scenario. In addition the measurements should be as precise as possible to provide the user with reliable data.

References

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