

A thesis for the Degree of Ph.D. in Engineering

Augmented Reality on Geometrically Changeable Paper

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Abstract

This research explores a technique for enhancing the integration between physical paper and digital information using augmented reality. Conventional augmented reality systems overlay virtual information onto planar objects such as paper. A piece of paper can be rotated and translated in front of a camera in order to view virtual contents in 6 degrees of freedom. However, people usually handle a piece of paper by folding or bending. For instance, people fold a piece of paper for holding it easily or bend it to follow the shape of their hands. Conventional augmented reality systems do not consider the change in the geometric property of paper such as folding and bending as natural interaction. Therefore, it is necessary to implement such interactions in order to enhance augmented reality.

Firstly, this work includes the modeling and recognition of folding, bending and cutting-based interactions on physical paper by applying a matching method. This work proposes an automatic recognition of the folding applied to physical papers and the transition between folded and planar condition. Secondly, the folding is extended into a bending interaction. Thirdly, regions recognition on paper is extended to allow the user to cut a piece of paper and track the pieces independently.

The system setup is then extended using projector-camera setup to allow the user to view the visualization directly on physical papers. In this case, the system can be implemented in larger area. By using the random dot marker technique, automatic content alignment is proposed. It allows the arbitrary movement of projector, camera and physical paper. As a result, it is not necessary to fix the projector, the camera and the paper beforehand and the time-consuming pre-calibration procedure can be avoided.

The proposed method is applied in order to realize the visualization of geographical information on physical paper maps. User can fold, bend, and cut a piece of paper map for interacting with virtual contents. A system architecture for building augmented maps applications that retrieves the geographical information from the Internet is presented. Using the proposed system architecture, the paper map and the virtual contents can be retrieved on demand so that the augmented maps application of any location can be made. Moreover, in order to support the user mobility and recent devices, the implementation of augmented maps on mobile phones is explored. Furthermore, the interaction of augmented maps is also explored by realizing pointing and tapping gestures.