Categorization and Recommended Use of AR in Cultural Heritage Application

AR在文化遗产中的应用分类及通用解决方案

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Introduction

Augmented reality (AR) has been widely used in many fields, especially in cultural heritage [1], which provides people a motivation to learn history and helps to protect cultural heritage as shown in figure 1 [2]. AR facilitates the revolution of cultural heritage reconstruction and exhibition. Meanwhile, different surroundings and environment of cultural heritage promote the development of AR technique as well. Because that AR in different application and project faces different reconstruction solution, a widely-used reconstruction solution with optimal properties in the similar cultural heritage conditions. Although the growing AR utilization in cultural heritage, including Kalman filter and Particle filter, few research has generated a universal method to similar situations and no review categorized the AR method utilized in cultural heritage. Researchers always focused on one individual application and gave one specific solution. The previous AR method applied on cultural heritage reconstruction should be synthesized and classified into its fit application scenarios, which can offer a clear understanding of different AR method for researchers. Because of the tracking process or pose estimation is the central question in AR reconstruction, thus, in this poster, I will analyze and classify two main AR tracking methods, Kalman filter, and particle filter, from literature and find a recommended AR solution with desired properties in some similar applications. This review of literature can helps researchers to choose the suitable method in their projects and improve the algorithm in this field.

Research Question

What is the all-purpose AR method in cultural heritage reconstruction with properties of robustness, speed, and compatibility?

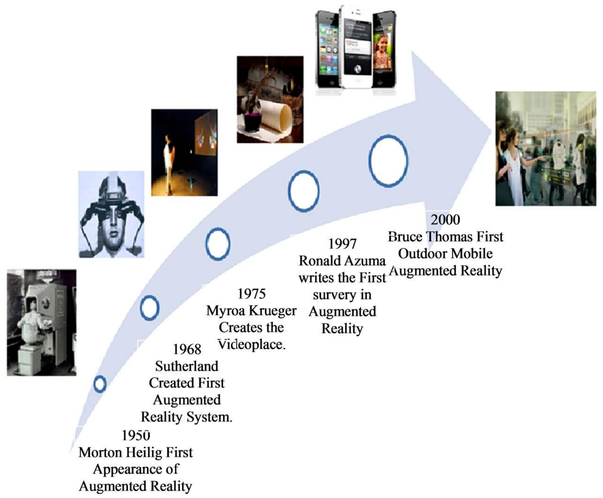
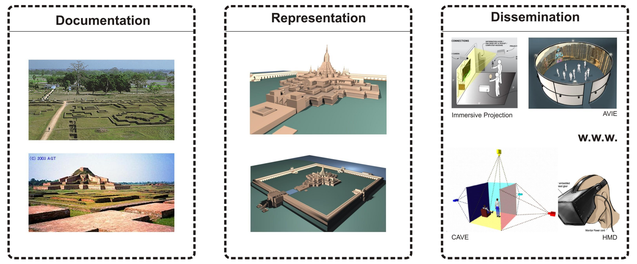


Fig.1: Augmented reality throughout history [2]

Cultural Heritage Application

Markers is a simple and useful way in cultural heritage reconstruction. The data from markers can be obtained by camera directly and then be processed to pose message. It is always used in museum exhibition [3] and reconstruct small-size-heritage and can be generated in headset devices [4]. To reconstruct ancient buildings or outdoor views, both image-based and sensor-based are allowed. Position information can be obtained by GPS or inertial Sensor like Kinect, meanwhile, the exact view will be captured by the camera. The portable device equipped with a camera and multiple sensors could be more practical for outdoor tracking.

Fig. 2: Various domains of AR cultural heritage reconstruction [5]



Tracking Method

To fuse visual and realistic scene, pose tracking is needed in AR. Three tracking methods are used frequently, sensor-based tracking, vision-based tracking, and hybrid tracking. The goal of tracking is to match data from sensor or camera to clues in the database. To achieve that, we can use Kalman filter or Particle filter to determine the correspondence between data and real scene. The comparison of these two methods are listed in table 1.

Both Kalman filter and Particle method can process the message from sensors and camera. However, each one has its strong points. For Kalman filter, it is applied to reduce pose error caused by the jittering and delay in camera pose as well [6]. Some special Kalman filter also matters to tracking method. The Extended Kalman filter has better property than normal Kalman filter [7]. It can use an auto-calibrating line or point characters to modernize camera pose. Another kind of filter, error-state Kalman filter [4], can fuse the data from inertia sensors and camera. For particle filter, points and lines feature captured by the camera can be processed by particle filter to generate tracking result [8]. what's more, the features about color distribution in a video frame from the camera can be work as characters as well. The particle filter is good at treating the estimate problems with non-linear and non-Gaussian features. The particle filter is more robust and sensitive than normal Kalman filter and it is simpler to apply [9]. Also, it is more flexible on observation models than Kalman filter.

Conclusion

Two main kinds of AR method have been compared in this review. Kalman filter is widely used and has various forms. It can run on an embedded system, which can be designed as a immersed attraction with headset devices in the museum. Particle filter has a better feature than Kalman filter, which can be used when speed and precision are highly needed.

Methods	Data Source	Principle	Application	Robustness
Kalman filter	Sensors/ camera	Decrease jittering and delay	Embed usage Adapt to textured objects (such as pottery with patterns)	Need other method to apply
Extended Kalman filter	Camera	Linearizing the measurements of auto-calibrated line & point characters and evolution models	To update the camera pose by auto-calibrating point or line features	Robustness to geometrical distortion and to light changes
Error-state Kalman filter	Inertia sensors/ camera	An extended Kalman Filter created for the error state occurred in linearizing a model, transit error-state to real state	Data fusion from an inertia tracker with data from a camera that tracks visual markers	Robustness need to be strengthened
Particle filter	Handheld camera	Sequential Monte Carlo methods based on point mass (or "particle") representations of probability densities	Non-linear models in state equation and measurement relation and a non Gaussian noise assumption	Better than Kalman and can be applied to any state-space model

Table 1: contradiction between Kalman filter and Particle filter

Future Research

For future research, I am suggesting the application of the existing method to a new area of study. This is because, in my project, I am applying AR method and devices to reconstruct cultural heritage. In my research, I found my research will improve the customers' experiences and present cultural heritage to people. The artificial intelligence and computing visual can be integrated into cultural heritage reconstruction as will.

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