# Problem Definition

## Introduction

In modern cities, more and more public places (e.g. a big shopping mall, university, library etc.) have been being built up for bringing convenience to people’s life. Although lots of services can be provided with a large size of indoor environment, people tend to lose their way when walking within it. The survey conducted by Olsson et al. [1] also shows that the AR indoor navigation related expectation from customers like locating the ATM service, is really significant. Due to the increasing trend in requirement for indoor positioning, many large IT companies have moved their concentration from outdoors to indoors [2].

## Project Aim

The aim of this project is to build a mobile AR application consists of indoor navigation and contextual information displaying.

## Project Objectives

It contains three objectives.

First, to build a mobile app for building visitors, through which users can quickly locate their current position indoor as well as see detailed contextual information of objects in real world shown on real-time vision from camera.

Second, to build a navigation system to direct users to the targeting place. The direction is dynamic according to the users’ current position and orientation.

Third, to build a data collecting system for building owners to input data of the building.

## Value Proposition

Although several prototypes have been raised by researchers, there is still no general and convenient application for providing indoor positioning service.

# Literature Reviews

## Problem Analysis

To achieve the goal of quick exploration for an unfamiliar building, current position of users as well as the information of indoor objects should be provided to users. Thus this part will be elaborated in two sub-parts: data presentation and navigation.

### Data presentation

The difficulty of data presentation is that it should choose a proper form of interface that could help users strongly feeling the sense of tie between a real object and that virtual one on GUI. In conventional information application (e.g. google map), text information often displayed onto a 2D map or along with a picture. This kind of GUI some time is difficult for users to identify the related object in real world. This problem can be solved if the software includes real vision into the its GUI. By employing AR technology to enhance the user experience, people can gain information what they want directly from real vision on camera live capture.

### navigation

With the consideration of AR interface, navigation function of the information kiosk should at least fulfill two requirements: keep track of users’ real-time perspective and display navigation information according to users’ current position. Due to the poor performance of GPS in indoor environment, professionals employ other technologies to achieve the positioning goal. They can be roughly classified into 3 groups [2]: 1) Signal-based positioning, such as WIFI, Bluetooth and cellular wireless connection signal. 2) Sensor-based positioning, such as IMU and camera (often related to AR). 3) Combination of both, such as AR+IMU, WIFI+AR. Although the first kind of the technology can even reach high accuracy of 1 - 2 cm according to the evaluation done by Khoury and Kamat [3] , it is usually expensive in deployment of devices, neither keeps track of users’ orientation nor provides well user experience. The rest two kinds of positioning technologies are the result that researchers have been trying to take advantages of advances of recent smartphones, which have multiple built-in sensors. Camera-based positioning technique is intrinsically compatible with AR and now becoming dominant in this filed [4]. Several works just combined camera-based poisoning and AR into a navigation system for providing a better user experience. Note that in applications of the third kind of techniques, people often use sensors or signals to calibrate the deviation from the actual position of devices and it is not much different from the first two.

## Related Technologies

Augmented Reality(AR) technology is to provide a graphical interface to users with real world perspective superimposed upon by or composited with virtual objects in real-time [5]. It could be used to supplement information, which can not be obtained from general perceptions, to objects in real world. This feature is very powerful to an information kiosk application no matter in navigation or providing other information. With reference from [6], the author decomposes an AR navigation system into three parts: 1) a Database. It stores feature patterns (also called markers) that extracted from real vision by data collectors. 2) A client app. a specific app installed in users’ smartphones that can detect pre-defined markers through cameras and send frames captured by cameras to a server for an information request. It also can augment the reality by drawing virtual objects or text and binding them to the related real objects. Part 3, a data processing program run on a server that receives those frames, matches them with samples in database and send back results to users’ smartphones after calculation. For convenience, the author classifies these techniques into 2 groups by types of referenced markers: 1) Use references from artificial markers. Since the patterns of artificial markers such as barcodes are really distinguished from nearby environment, they are much easier to be recognized, making the system stable and robust. However, artificial markers are aesthetically defective and the installment of them may be cumbersome. 2) Use references from natural markers. Static objects like doors, windows or room tags can be considered as referenced points for estimation of locations of devices. Although the complexity of the system is increased, it exempts the installation of artificial markers from the construction of such positioning system and gives more natural sense to visitors walking within the building. Hence, this paper will focus on how to provide information to users with references from natural markers.

## Existing Solutions

This section mainly discusses about the existing solutions which consists of AR as its main data presenting component. Although many of them focus on camera-based positioning techniques, their achievement still valuable to this project.

Neges et al. [7] have proposed a solution using natural markers(e.g. exit signs) combined with IMU for error calibration. However, users have to set a starting point before the navigation process.

Xiao et al. [8] described a system using static objects(e.g. doors) as referenced points in a relatively large indoor environment. Although this system doesn't employ AR to represent position information, its algorithm for calculating the position of smartphone is still valuable to AR indoor navigation system.

Kim and Jun [9] designed a system on mobile tablet PC that uses both artificial markers and natural scene as reference in navigation process. The system first obtains the starting position through scanning pre-installed artificial markers. Then in navigation part, it repeatedly captures live image sequence through users’ cameras which to be compared with sample image sequence on database. After matching process, the location information will be shown if users enter a new place where artificial markers are not installed on. However, this system requires more computational power so that it may affect user experience.

Harlan and Gaetano [10] described a system from another angle by using landmarks(e.g. floor-to-wall transitions) as references. Positions of devices will be determined after matching detected landmarks with those on floor plan. It combines WIFI positioning technology to reduce the task of matching computation. It can reach accuracy of 30 cm, but the matching algorithm is complicated.

Bae el at. [11] described a system using 3D point cloud model for references, which constructed from a set of site pictures. Although they improve the performance of the model constructing process, it still needs sophisticated hardware support(server-side) and a relatively long time to build a 3D point cloud model.

For better user experience, the proposed system of this paper is mainly based on the first two solutions mentioned in this section.

# methodologies

References

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