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# 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 building, people tend to lose their way when walking within it. This problem includes two aspects:

First, the interior structure of a building is complicated with large size and a lot of facilities or services. Even for a worker of that building, it still has to consume lots of time to remember the position and other detailed information of those facilities and services.

Second, apart from those static objects, there are many dynamic objects/events within a building. Visitors who don't come to the building frequently will not know the changes of those objects/events.

These two aspects are all pointing to a fact that visitors have a delay in information acquisition. Thus the author believes that an information kiosk using AR to provide information to users instantly can solve the problem. The survey conducted by Olsson et al. [1] also shows that users are requiring an AR navigation app to solve the problem.

## Project Aim

The aim of this project is to build a mobile AR application consists of indoor navigation and contextual information presentation. It hopes that this project could help people achieve information about indoor objects instantly as well as reach target position more efficiently.

## Project Objectives

1. Design and develop a mobile app with AR.
   1. Design GUI and components for the app.
   2. Design and implement AR interaction
2. Design and develop a server-side program.
   1. Develop a function for object recognition
   2. Design and implement an algorithm for navigation
   3. Design and Implement communication between server and app.
3. Design database schemas.
   1. Design a schema for floor plan of a building.
   2. Design a schema for storing information of indoor objects/events
4. Design information input interface
   1. Design a web page GUI
   2. Implement database operation through the web page
5. Test and evaluation
   1. Test and debug the whole system
   2. Experiment and evaluation

## Value Proposition

Users will be the first group benefits from this system in terms of efficiency when exploring a building.

With this system, building manager can save money as they don't need to employ workers to give information guidance to visitors.

Although AR and indoor positioning technologies have been developed rapidly in recent years, there is still no general app that taking advantages of those technologies for a building exploration guidance in Hong Kong. This proposed system can fill the gap.

# 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

An effective GUI requires a proper form of information display which 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 for data presentation, people can gain what they want to know directly from real vision on camera live capture.

An introduction of AR will be in section 2.2.2.

### Navigation

With the consideration of using AR user interface just mentioned, 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]. It has its own advantages such as low-cost in deployment and ability of keeping track of users’ orientation. 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, sensors or signals are often used to calibrate the deviation from the actual position of devices and it is not much different from the first two.

### Problem analysis conclusion

Conclusion for discussion above is that camera-based navigation can seamlessly cooperate with AR to provide a better user experience in an information app for building. It can be combined with other sensors or signals for calibration.

## Related Technologies

This part will begin with a brief description of the proposed system, then followed with introductions of related technologies as well as difficulties of implementation and existing solutions for those difficulties.

### Brief description of the proposed system

With reference from [5], this paper designed three main components for the proposed system: 1) a Database. It stores feature patterns (also called markers) that extracted from real vision by data collectors. 2) A client app. It provides AR user interface, communicates with server. 3) A server-end program. It communicates with clients and retrieve data from database. Obviously, the second component needs a series of AR tools to detect environment and to draw virtual objects; the third component needs an algorithm for estimating users’ position from inputted photos or other optional data.

Details of the system will be elaborated in section 3.

### Related technologies and difficulties

Just as mentioned in last section, related technologies are AR and camera based positioning.

The concept of 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 [6]. It could be used to supplement information, which can not be obtained from general perceptions, to objects in real world. The difficulties are that it requires robust graphic recognition and proper placement of virtual objects which result in an illusion that those objects are naturally parts of the real environment.

Camera-based positioning means that users’ positions are estimated from photos captured by their cameras. Note that this technology is built up upon the graphic recognition which is also the base of AR application. The difficulties are that it requires well references planning and high performance in positioning computation.

## Existing Solutions

### AR tools

Recent years, several AR toolkits have been introduced to software developers. Among them ARKit [7] and ARCore [8] are useful for developing mobile apps development. ARKit is introduced by Apple company and packages device motion tracking, real world understanding and other AR related functions. However, it can only be applied to apple’s apps. ARCore is introduced by google company and serves the similar functions as ARKit does. It is a multi-platform framework.

### Camera-based positioning with different references

The main difference of each existing solutions is the type of markers it references to[4]. For convenience, this paper classifies these solutions into 4 groups by types of references:

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 samples of images. Just as described in [9] and [10], the samples can be a set of pictures taken for designated markers or videos taken for the scene when data collectors walking through the whole environment. The system of this kind of solutions is simpler than the others but not robust.

3) Use references from extracted features. Just as described in [11] and [12], those features can be physical points on surface of indoor static objects (e.g. floor-to-wall transitions). It often includes feature points matching calculation that increasing complexity of the system, but in the meantime bring robust and efficiency.

4) Use references from 3D model. Just as described in [13]. Since the constructing process of a 3D model is really time consuming, this paper will not take this solution into consideration.

For better user experience, this paper is going to take advantages of the second and the third solutions for constructing the proposed system.

# Preliminary methodologies

In principle, the basic methodology for this project is Build-and-Test.

## Technologies for this project

It is also going to use some essential tools for system prototype construction. It contains:

1) ARCore, the toolkit that provides API for developing mobile app.

2) MongoDB, the database that can store data of objects flexibly.

3) Web page technologies, which can form an entry for building managers or users to input information of indoor objects.

4) Navigation algorithm, which can estimate users current position according to inputted camera captures and give direction suggestions. It is based on features extraction and matching.

## Preliminary design of the proposed system

As shown in Fig1, the proposed system contains 4 big components. Data flow through all the system as shown in Fig 2.

Within Mobile App scope, ARCore is responsible for processing cameras’ input, communicate with server and drawing virtual objects onto GUI based on its own understanding of indoor environment.

Within Server-side Program scope, Object Recognition program in server receives images from clients and figures out objects identities on images after matching with data stored in database. Information Service will be asked by Object Recognition to search data in database and save the correct results sent from Object Recognition. After computation based on those objects identities results, navigation or other information will be sent to Mobile App.

Database will store features extracted from sample pictures, objects related information and floor plan of a building.

Web Entry is only for information operation such as update.

Sever-side Program

Mobile App

Web Entry

MongoDB

Figure 1

Camera

ARCore

GUI

Information Service

Object Recognition

Navigation

Data Retrieval

database

camera

ARCore

Live capture

GUI

Virtual objects

Object recognition

Live capture

Information service

Object identity

Related information

Navigation computation

navigation

position information

All information

Figure 2

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# Appendix A. Project Plan

