COLOUR CONSTANCY FEATURE DETECTION AND MATCHING TECHNIQUE FOR WIRELESS LAN/CAMERA INDOOR POSITIONING SYSTEMS

WAN MOHD YA'AKOB BIN WAN BEJURI

UNIVERSITI TEKNOLOGI MALAYSIA

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WAN MOHD YA'AKOB BIN WAN BEJURI

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"To my beloved family: Syarifah Abidah Qamrunisa binti Wan Mohd Yusop, Wan Bejuri bin Wan Hamid, Sharifah binti Mohd Yusop, Sharifah Norkiah binti Wan Abang, Wan Mohd Shaiful Nizam bin Wan Bejuri, Sharifah Shamsiah binti Wan Bejuri, Sharifah Syariyah binti Wan Bejuri, Sharifah Syahirah binti Wan Bejuri, Wan Yusup bin Wan Hassan, Sharifah Hamidah binti Wan Hamid, Syed Mohd Rusydi bin Wan Yusup, Sharifah Nurulhuda binti Wan Yusup, Sharifah Hafizah binti Wan Yusup, Sharifah Hazirah binti Wan Yusup, Syed Mohd Fadhli bin Wan Yusup, Syed Mohd Azhar bin Wan Yusup, Syed Mohd Syahmi bin Wan Yusup, Sharifah Nurazan binti Wan Yusup, Wan Razali bin Wan Hamit, Sharifah Rohanah binti Wan Hamid, Syed Muhammmad Hafiz bin Wan Razali, Sharifah Nensiah binti Wan Hamid, Wan Hamri bin Wan Hamid, Syed Hossin bin Wan Hamid, Syed Abdul Rajak bin Wan Hamid, and Sharifah Habsah binti Wan Hamid"

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ABSTRACT

The location determination system in a changing environment, especially in an indoor environment can be very challenging if Global Positioning System (GPS) signals are blocked. It is necessary to combine or integrate multiple sensors and positioning methods in order to provide better location determination service to detect these signals. One of the most common platforms for this service is mobile phone technology which uses Wireless Local Area Network (WLAN) and camera. These positioning technologies allow determination of positioning information but the approach to the integration of WLAN and camera positioning feature detection and matching suffers from the illumination environment in the hallways of building. In this study, a positioning technique of colour constancy feature detection and matching for WLAN/Camera positioning was designed using colour constancy feature detection and matching to improve location determination in the illumination environment. The results showed the proposed design provides better location determination in the illumination environment (difference of no solution averaging: 12.9%) than Harlan Hile's method. This research has proven that the proposed design will significantly contribute to the modernization of a location determination system.

ABSTRAK

Sistem penentuan lokasi di persekitaran yang berubah-ubah, khasnya di kawasan di dalam bangunan, adalah sangat mencabar kerana isyarat Sistem Penentu Kedudukan Global (GPS) terhalang. GPS sesuai untuk digabungkan atau diintegrasikan dengan pelbagai pengesan dan kaedah penentu kedudukan bagi menyediakan servis penentu lokasi yang lebih baik. Salah satu platform yang kerap digunakan untuk servis ini ialah teknologi telefon mudah alih yang menggunakan Rangkaian Tempatan Tanpa Wayar (WLAN) dan kamera. Kedua-dua teknologi penentu kedudukan ini membenarkan maklumat penentu kedudukan tetapi penekanan terhadap pengesanan dan penggabungan ciri bagi integrasi penentu kedudukan WLAN dan kamera adalah sukar dalam persekitaran beriluminasi di kawasan koridor bangunan. Dalam kajian ini satu teknik penentu kedudukan telah direka menggunakan teknik pengesanan dan gabungan ciri warna malar untuk meningkatkan penentuan lokasi dalam persekitaran beriluminasi. Hasil kajian menunjukkan cadangan rekaan ini memberikan penentuan lokasi yang lebih baikdalam persekitaran beriluminasi (perbezaan 'tiada penyelesaian':12.9%) berbanding kaedah Harlan Hile. Kajian ini membuktikan rekaan yang telah dicadangkan akan menyumbangkan permodenan (penambahbaikan) kepada sistem penentuan lokasi.

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LIST OF SYMBOLS

G	Gaussian
σ	Sigma (constant)
j	Flux
$\nabla_{\mathrm{u.D}}$	Tensor
d	Scalar Diffusivity
q	Output Image
I	Image
p	Input Image
W_{ij}	Guided Filtering Kernel
K_i	Normalizing Parameter
p^k	Inliers Sample
S	Trials
k	Correspondences Subset for RANSAC
ss	Signal Strength
λ	Surfaces Reflectance
k	Constant
$\max f(x)$	Maximum of reflectance in RGB
e	Light Source Colour
Γ_c	Illumination Chromaticity
σ_c	Image Chromaticity

I_i	Image Intensity
w_d	Geometrical Parameters
Pr	Received Power
d_0	Reference Distance
n	Path Loss Exponent

LIST OF ABBREVIATIONS

1D	One Dimensional
2D	Two Dimensional
ANN	Artificial Neural Network
AR	Augmented Reality
CCFDM	Colour Constancy Feature Detection and Matching
FGGD	Finite Generalized Gaussian Distribution
GPS	Global Positioning System
HH	Diagonal
HL	Horizontal
INS	Inertial Navigation Systems
LBS	Location Based Services
LH	Vertical
LL	Lower Resolution Approximation Image
LMS	Least Median Square
NLDF	Nonlinear Diffusion Filtering
NNSS	Nearest Neighbors in Signal Space
RANSAC	RANdom Sample Consensus
RF	Radio Frequency
RGB	Red Green Blue
RSSI	Received Signal Strength Indicator

SIFT	Scale Invariant Feature Transform
SS	Signal Strength
WLAN	Wireless Local Area Network
WLAN/Camera	Hybrid between WLAN and Camera
WLS	Weighted Least Square

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Knowledge of the location position is a common requirement for many people. Over the last few years, much research and development has taken place concerning location-based services (LBS), which could now be supplemented and expanded with the help of ubiquitous methods, and possibly even replaced in the future. The positioning and tracking of pedestrians in smart environments is achieved differently to the use of conventional navigation systems, as it is no longer only passive systems, which execute positioning on demand, that need to be considered.

Approaching location positioning technologies can be used to track people in various environments, and also make the location information can be managed effective and efficient since the decisions play critical role in the strategic design of supply chain networks[1][2][3][4][5]. Therefore, developing efficient tools to guide the location phase of the decision-making process is crucial to improving supply chain planning and control[6][7][8][9][10]. Thus, both low- and high-level technology is required, with a broad range of attributes necessary to adequately provide such diverse services[11][12][13][14][15].

Basically, the mature location positioning technology (which is GPS) has been widely used [16][17][18][19][20][21][22][23]. However, this technique is suffered in obstructed environment (example: in an indoor environment)[24][25][26][27][28][29][30][31][32][33]. Thus, this technique has been improved by many researchers in order to make it accessible anywhere or everywhere (in other words: ubiquitous positioning) including obstructed environment. In addition, objects such as trees, high buildings, high walls and even people walking may constitute an obstruction to the signal. These obstructions sometimes fool the system into believing that the user has moved to another location; this usually happens in indoor environments, and makes it hard to estimate the user's position. Therefore, there is a need for an alternative method which ensures that users can locate themselves inside buildings as well as outdoors (for example, a visitor may want to find a friend in a complex office building).

In [34], has been explained deeply about the concept of ubiquitous positioning. According to [35], the aim of this concept is to deliver a 'calm technology' for user without involving any complicated configuration task. Initially, the idea originated from ubiquitous computers in 1988; a global system of interconnected computer networks that used the standard Internet Protocol Suite (TCP/IP) to serve billions of users worldwide, acting as a sharing agent to make the information available to be accessed anywhere and everywhere[36].

In order to deliver a ubiquitous positioning system, all aspects of the ubiquitous awareness environment need to be considered, such as communication, storage, and the capability of the device itself [37][38][39][40][41][42]. Moreover, a combination of positioning methods should be the basis for a ubiquitous navigation system[43][44][45][46][47][48][49][50][51][52]. Each positioning sensor helps the others, in order to produce absolute positioning information when the positioning system is in a situation where one of the combination sensors is not functioning effectively.

The most famous idea behind ubiquitous positioning is integration between GPS and other indoor positioning technology. The integration of GPS with other positioning sensors may help to solve this issue by making positioning information more intelligent, reliable and ubiquitous. Although the integration of GPS with external sensors, such as the inertial navigation system (INS) is quite successful in terms of navigation inside buildings, this solution is not very effective in solving this issue, as it may cause end users to feel badly towards device integration. Integration with external sensor sis mostly quite successful in terms of positioning accuracy, but not particularly when it comes to mobility. On the other hand, the integration of GPS with internal positioning sensors such as WLAN, camera or Bluetooth may solve this problem. It is also capable of giving users more details about the location by navigating from anywhere, rather than only from tracking in certain areas and environments.

In this study, a new technique, known as colour constancy feature detection and feature matching, has been designed for the WLAN/camera positioning system at the Faculty of Computer Science & Information Systems (Level 3, Block N28), Universiti Teknologi Malaysia, Johor. The input from the camera is extracted in order to obtain the feature interest (corner), and at the same time, the input from the WLAN is extracted to obtain the WLAN positioning coordinates. This extracted information is then processed by integrating this information, which provides absolute positioning information.

The expected outcome of this research will significantly contribute in modernization of location determination system. In addition it is also contribute to the current studies of WLAN/Camera positioning system field.

1.2 Statements of Problems

One of the most successful indoor positioning solution in term of mobility and pervasive is solution using integration between Wireless Local Area Network (WLAN) with camera positioning[53]. This solution however it is suffer in illumination environment in building hallway. In this research, the focus is on the poor illumination environment issue that occurs inside buildings [53]. Poor lighting or poor illumination environments can caused the interest point detection on the captured image cannot easily recognized. Thus, the data from camera (interest point detection on the captured image) cannot be integrated with WLAN signal strength , finally will make the WLAN/camera positioning system unable to deliver positioning information. To make the system can deliver positioning information, both of the input data (WLAN signal strength and captured image, which is the hallway and door must visible on the captured image) can be obtained in the experimented location [53]. The situation of positioning system that cannot deliver positioning information is known as a “no solution” situation; a higher “no solution” percentage means that there is a higher chance that the WLAN/camera positioning system will be unable to determine positioning information. Thus, by reducing the percentage of “no solution” situations, the performance of WLAN/camera positioning in determining positioning information can be improved.

1.3 Research Objectives

The major aim of this study is to establish a new feature detection and matching technique for WLAN/Camera positioning that can determine location in the illumination change environment (by reducing illumination error), in order to ensure WLAN/Camera positioning can operate in the various environment.

The sub-objectives are specified as follows:

(i) To investigate previous feature detection and matching technique [43].

(ii) To develop the new feature detection and matching technique (which named as colour constancy feature detection and matching):

(iii) To evaluate the new developed feature detection and matching technique.

1.4 Scope of Study

(i) Selection of study area

The study was conducted in Universiti Teknologi Malaysia, Johor, using a specific building: the Faculty of Computer Science & Information Systems (Level 3, N28, FSKSM). The location is shown in Figure 1.2. Basically, it is consist of Area 1 and Area 2. The reason to choose this study area is the data that collected in this area is suitable and meet requirement for this research (please see section 1.4 (iii) for location environment). The detail of this areas will described at Chapter 3.

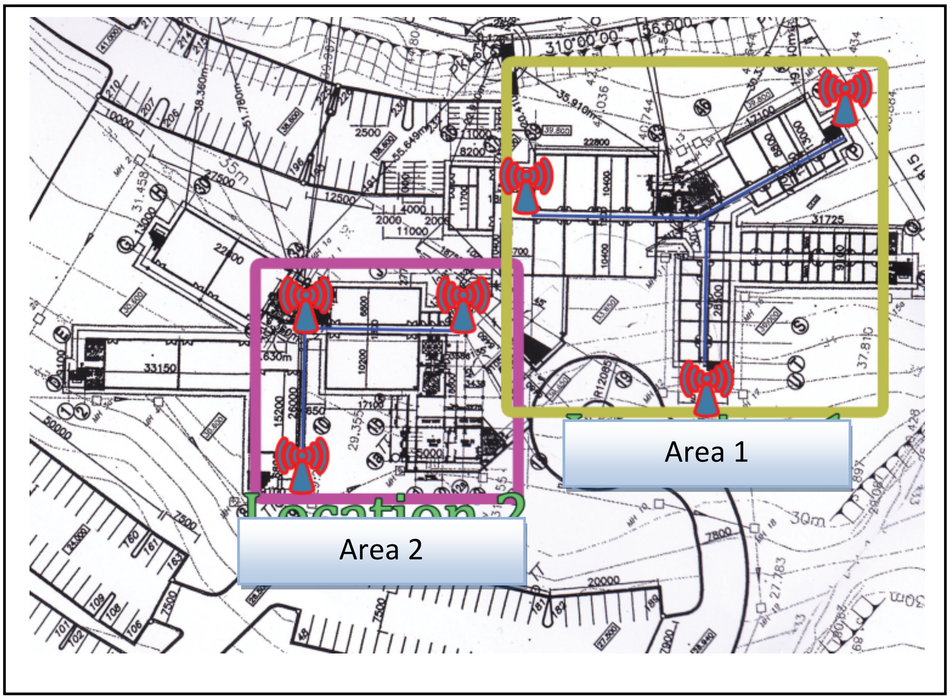

Figure 1.1: Research Area

(ii) Device and hardware limitation

The data WLAN strength and image data was collected by using Personal Digital Assistant (PDA) HTCHD Mini model which is equipped of camera and WLAN function (the purpose of the camera and WLAN is to capture corridor image and WLAN signal strength). The technique will be run using personal computer (Personal Computer Specification:

Pentium 4, DDRII, 250 GB SATA Hardisk Storage). The wireless access point that used this research is 3COM.

(iii) Location Environment

The data in the form of WLAN Signal Strength and image was collected at the building corridor (the image must visibly have feature such as door and hallway so that intersection of microlandmark can be made) [53].

1.5 Significant Of The Study

The establishment of the colour constancy feature detection and matching for WLAN/Camera positioning are able to provide several benefits such as:

(i) Colour constancy feature detection and matching for WLAN/Camera positioning will be delivers a modernization of location determination system.

This proposed technique can be implemented for user needs (especially in asset tracking management) in order to ease their task management on site. By implement to the end user, it is can make the location information of asset can be tracked in many various environment (including illumination environment)compared to the previous research, and the same time maintaining the same basic framework feature which can be supporting the existing system.

(ii) A new research medium in WLAN/Camera positioning system field.

Through this research, the development of a new WLAN/Camera positioning system will be experienced. The developed technique can be modified to improve its performance and troubleshooting will be easily traced and handled in order to suit other WLAN/Camera positioning system cases.

1.6 Organization of Chapters

The thesis are reported into six (6) chapters as shown as Figure 1.2: Chapter one (1) is an essential introduction to the research. It will help to highlight the research background, objective, problem statement, scope etc. Chapter two (2) provides background information and a review of related literature that leads to the formulation of the research problem.

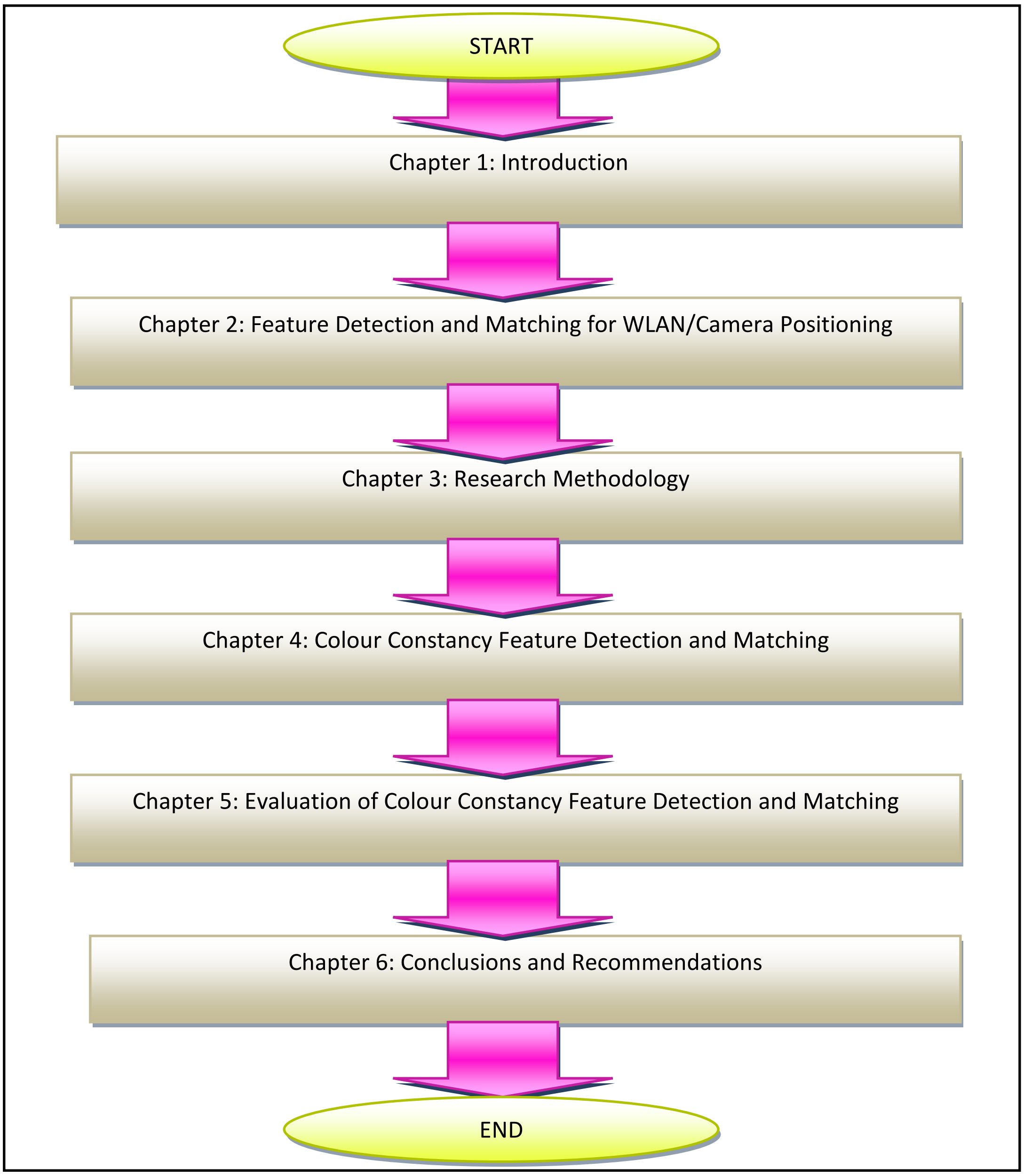

Figure 1.2: Organization of the Thesis

It dedicated to basic concept of WLAN/Camera positioning, taxonomy of feature detection and matching and detail of case study about feature detection and matching in positioning technology. Chapter three (3) consists of research methodology adopted for the study. Chapter four (4) provides the proposed method (which known as Colour Constancy Feature Detection and Matching). Chapter five (5) contains the results of the evaluation of colour constancy feature detection and matching. Finally, chapter six (6) presents the summary, conclusions and recommendations of the research.

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