AUTOMATIC PAN-TILT CAMERA POSITIONING SYSTEM FOR MOTION TRACKING

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Dedicated to my beloved parents,

brothers and friends ...

Thanks for your continuous support and encouragement.

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ABSTRACT

In this project, a pan-tilt unit (PTU) which is actuated by two DC motors is used as part of the motion tracking camera system. A camera is mounted on the PTU and the PTU is responsible to move the camera according to the output from the motion tracking algorithm. Accuracy and speed are the two concerns when the PTU is moved because the motion tracking camera is expected to track a single moving object and keep it at the centre of the field of view. A pan-tilt camera positioning system has been developed to meet the characteristics of the motion tracking algorithm and some other hardware constraints. The technique implemented to realize the pan-tilt camera positioning system is an open-loop control called coordinate to motion unit translation. The video frames which are at the size of 256 pixels times 256 pixels are indexed into 392 motion units, which are the points that the camera will centre each time it is being moved. This technique has enabled the manual directivity feature even when the pan-tilt camera is still moving and in the meantime preserves the accuracy of the system. The testing results of the system developed have shown that the motion tracking camera has an accuracy of ±10 pixels and was able to track a moving object travelling at the speed less than 85 pixels per second.

ABSTRAK

Dalam projek ini, satu unit “pan-tilt” (PTU) yang digerakkan oleh dua motor DC digunakan sebagai sebahagian daripada sistem kamera jejak pergerakan. Sebuah kamera dipasangkan pada PTU tersebut dan PTU itu bertanggungjawab untuk mengerakkan kamera tersebut mengikut output daripada algoritma jejak pergerakan. Kejituan dan kelajuan merupakan dua faktor yang penting apabila PTU tersebut digerakkan kerana sistem kamera jejak pergerakan perlu menjejak satu objek yang sedang bergerak dan mengekalkannya di tengah-tengah rangka video. Satu sistem memposisi kamera “pan-tilt” telah direka supaya bersesuaian dengan algoritma jejak pergerakan dan faktor-faktor perkakasan berkenaan. Teknik yang digunakan untuk menghasilkan sistem memposisi kamera “pan-tilt” tersebut merupakan sejenis kawalan gelung-buka yang dinamakan translasi koordinat kepada unit pergerakan. Rangka video yang bersaiz 256 pixel darab 256 pixel dibahagikan kepada 392 unit pergerakan, yang merupakan titik-titik yang diketengahkan oleh kamera setiap kali kamera bergerak. Teknik ini membolehkan arahan pergerakan kamera secara manual sungguhpun kamera masih dalam pergerakan, tetapi masih mampu mengekalkan kejituan sistem. Keputusan semasa menguji sistem yang dibangunkan ini menunjukkan sistem kamera jejak pergerakan ini mempunyai kejituan ±10 pixel dan dapat menjejak objek yang bergerak dalam kelajuan kurang daripada 85 pixel per saat.

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AC	-	Alternating Current
CCTV	-	Closed Circuit Television
CIS	-	Central Inference System
CVVIP	-	Computer Vision, Video, and Image Processing
DC	-	Direct Current
DTVSS	-	Discrete-time Variable Structure Systems
FPGA	-	Field Programmable Gate Arrays
LSB	-	Least Significant Bit
MSB	-	Most Significant Bit
PC	-	Personal Computer
PI	-	Proportional-integral
PTU	-	Pan-tilt Unit
SPS	-	Spatial Positioning System
VS	-	Variable Structure
VSC	-	Variable Structure Controller

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CHAPTER I

INTRODUCTION

1.1 Introduction

Our world has become a digital world. Many products around us incorporate digital technology. Cars, cameras, and computers all utilize digital technology. Surveillance system without any exception has also been evolving in the past few decades, from analog to digital, from analog CCTV to digital CCTV, and has been incorporated with a wide range of accessibility. One of the state-of-the-art technologies of surveillance system is the motion tracking camera system. Motion tracking camera, as its name suggests, will follow a moving object and will keep the target in the centre of the field of view. This is especially useful in video conferencing and security surveillance.

Cameras are traditionally manually controlled. It focuses on one point in space unless somebody turns it. Often times, however, this is neither useful nor convenient. For example, suppose the security services is trying to protect a building, in order to

cover a fairly small region, either many cameras are installed, or human supervision is constantly needed, or both. Since emergencies happen rather infrequently, most of the time, the guards or video tapes are wasted. Such problems can be solved if we have a motion tracking pan-tilt camera.

A pan-tilt camera is a stationary but rotating camera, where pan means rotating along the azimuth angle and tilt means rotating along the elevation angle. A motion tracking pan-tilt camera is able to track a moving object, thus avoiding the object from getting lost from sight. It is especially useful and convenient for security surveillance and video conferencing. For example, having a motion tracking pan-tilt camera during a video conference, we don't have to sit still in front of the camera but can move around a room and the camera will track us down. Figure 1.1 shows a pan-tilt camera and the definition of "pan" and "tilt".

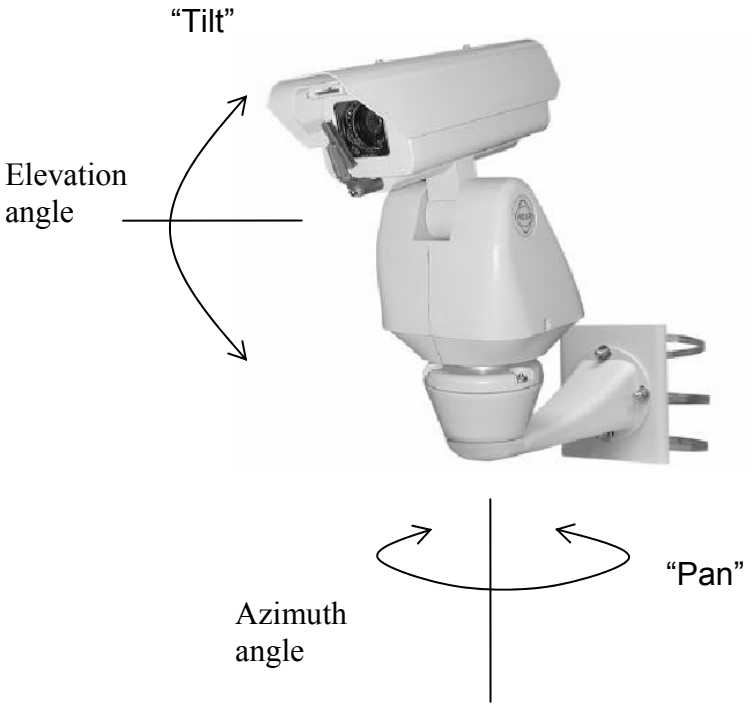

Figure 1.1 : The Definition of "Pan" and "Tilt" of A Pan-tilt Camera

1.2 Project Background

The project to develop a motion tracking camera system was initiated in year 2001 by a group of researchers in Computer Vision, Video and Image Processing (CVVIP) research unit at the Faculty of Electrical Engineering of University of Technology Malaysia. The system however, has poor performance and could not track accurately. The pan-tilt camera could move when a moving object was detected, but has low accuracy and was not able to keep it at the centre of the field of view.

It was identified that the problem was with the pan-tilt camera positioning system. The motion tracking algorithm was actually performing as required, but the camera positioning system was unable to produce accurate and fast performance.

The project explained by this thesis was to look into this matter, thus developing an effective positioning system that is able to response accurately according to the output of the motion tracking algorithm.

1.3 Objective of Work

The objective of this project is to accurately track a single moving object using a pan-tilt camera. To accurately track a single moving object means to keep a moving object at the centre region of the camera view.

1.4 Scopes of Work

In order to be able to achieve the stated objectives, the scope of the project is limited to the following:

i. Develop an algorithm using Visual C++, for controlling a dual DC motor pan-tilt camera mounting.

ii. Incorporate the relay-motor pan-tilt mounting to an existing motion tracking program which is written in Visual C++.

iii. Control the above mounting through the parallel port of a PC.

iv. Enable the camera view to follow a single moving object.

1.5 Layout of Thesis

In Chapter II, a presentation regarding the main components of a motion tracking camera system will firstly be done. This is followed by descriptions about the motion tracking algorithm used in system developed in this project. Most importantly, the descriptions of previous works and existing methods regarding the scopes of this project will also be included.

Chapter III explains the techniques and methods that are used to develop the pan-tilt camera positioning algorithm. The algorithm and the program flow of the pan-tilt

camera positioning system will also be explained. Some relevant characteristics and constraints of the components of the system concerning the development of the algorithm will first be described.

In Chapter IV, the outcome of the works of this project and the results of the implementation of the methodology in Chapter III will be presented. The performance in terms of accuracy and speed of the system developed will be discussed. Besides that, the limitations of the system will also be listed.

The thesis is concluded by Chapter V, where the conclusions drawn from the study as well as some recommendations for future works are presented.

REFERENCES

1. Boyoon Jung and Gaurav S. Sukhatme (2004). Detecting Moving Objects using a Single Camera on a Mobile Robot in an Outdoor Environment. *8th Conference on Intelligent Autonomous Systems*. March 10-13, 2004. Amsterdam, The Netherlands: University of Southern California. 980-987.

2. J. Hu, D.M. Dawson and K. Anderson (1995). Position Control of A Brushless Dc Motor Without Velocity Measurements. *IEE Proc.-Electr. Power Appl.* Vol.142, No 2: 113-122.

3. J. Weng, P. Cohen, and M. Herniou (1992). Camera Calibration with Distortion Models and Accuracy Evaluation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 14(10): 965-980.

4. Jianyong Niu (2002). *Prototyping A DC Motor PI Controller Using Field Programmable Gate Arrays.* University of Sheffield: Master Thesis.

5. Keith Jones (1994). *IEC 1131-3 Programming for Motion Control.* Savoy Place, London: IEE.

6. Luigi Di Stefano and Enrico Viarani (1999). *Vehicle Detection and Tracking Using the Block Matching Algorithm*. Italy: University of Bologna.

7. Makoto Iwasaki, Kenta Seki and Hiromu Hirai (2000). *Fast-Response Positioning Using H Control in Machine Tools.* Nagoya, Japan: Nagoya Institute of Technology.

8. Olivier Faugeras (1993). *Three-Dimensional Computer Vision - A Geometric Viewpoint*. MA: MIT Press, Cambridge.

9. P. M. Ngan and R. J. Valkenburg. *Calibrating a Pan-tilt Camera Head*. Auckland, New Zealand: Machine Vision Team, Industrial Research Ltd.

10. P.R. Moore and C.M. Chen (1994). *The Syncronisation of Servo Drives Using Fuzzy Logic Control*. Savoy Place, London: IEE.

11. Phaik Yong. Y (2003). *Accurate Real-Time Object Tracking With Linear Prediction Method*. UTM: Master Thesis.

12. R. Y. Tsai and R. K. Lenz (1989). A New Technique for Fully Autonomous and Efficient Robotic Hand/Eye Calibration. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 5(3): 345-358.

13. Robert J. Valkenburg (1995). *Classification of Camera Calibration Techniques*. Auckland, New Zealand: Machine Vision Team, Industrial Research Ltd.

14. Zoran Jovanovic and Goran Golo (1997). Dc Motor Position Control By Discrete-time Variable Structure Controllers. *Mechanics, Automatic, Control and Robotics.* 2(7): 291-300.

15. J. Shi, C. Tomasi (1994). Good Features to Track. *Proceedings, IEEE Conference on Computer Vision and Pattern Recognition.* 593-600.

16. A. L. Yuille, P. W. Hallinan, D. S. Cohen (1992). Feature extraction from faces using deformable templates. *International Journal of Computer Vision*. 8(2): 99-111.

17. John M. Gauch (1999). Image segmentation and analysis via multiscale gradient watershed hierarchies. *IEEE Transactions on Pattern Analysis and Machine Intelligence.* 8(1): 69-79.

18. H. Wechsler, Z. Duric, Fayin Li, and V. Cherkassky (2004). Motion Estimation Using Statistical Learning Theory. *IEEE Transactions on Pattern Analysis and Machine Intelligence.* 26(4): 466- 478.

19. J. Park, B. Jiang, and U. Neumann (1999). Vision-based Pose Computation: Robust and Accurate Augmented Reality Tracking. *IEEE International Workshop on Augmented Reality.* 3-12.