A VISION-BASED VEHICLE FOLLOWER NAVIGATION USING FUZZY LOGIC CONTROLLER

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by

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LIST OF ABBREVIATIONS

AF	Area Factor
BLDC	Brushless DC Motor
DP	Diametrical Pitch
ESC	Electronic Speed Controller
FOV	Field of View
FV	Follower Vehicle
GUI	Guided User Interface
HSV	Hue Saturation Value
I2C	Inter-Integrated Circuit (alt. I^2C)
ICT	Information and Communications Technologies
ITS	Intelligent Transport System
LV	Lead Vehicle
NumPy	Numerical Python
OpenCV	Open Source Computer Vision Library
PPM	Pulse Position Modulation
PWM	Pulse Width Modulation
RC	Remote Controlled
RMS	Root Mean Square
ROI	Region of Interest

RPM	Revolutions per Minute
SBC	Single Board Computer
SCL	Serial Clock
SDA	Serial Data
USM	Universiti Sains Malaysia

LIST OF SYMBOLS

A	Determined Area
AF	Accuracy Factor
A_m	Measured Area
α	aspect ratio
α_s	smoothing weightage parameter
β_s	trend weightage parameter
b_{roi}	ROI box
C_x	Centroid in x-coordinate
d	distance
d_δ	distance error
δ_{x_i}	raw input difference
ε	Error
e	gear train value
f	focal length
fov_x	field of view in x-plane
fov_y	field of view in y-plane
γ	camera tilt angle in radians
γ_s	seasonality weightage parameters
h	height in metre

h_f	frame height
k	regressor variable
k_1, k_2	radial distortion coefficients
κ	image-bit dependent constant
lim	limit
n	number of replicates
N	gear teeth number
n_F	speed of first gear
n_L	speed of last gear
N	pinion teeth number
p_1, p_2	tangential distortion coefficients
P	period
p_s	summation of coordinate points
p_w	pulse width
p_i	periodic component
p_{00}	minimum sum index
p_{11}	maximum sum index
p_{roi}	ROI points
θ	PWM angle
ρ	regression response variable
R_p	pull-up resistor

s	pixel highest sum
s_i	smoothed signal
SS	sum of squares
τ	motor torque
t_i	smoothed trend
u_0	optical center at x-coordinate in pixel
v_0	optical center at x-coordinate in pixel
w_f	frame width
x_0, y_0	origin
x_i	raw input
x_{dr}	radial distortion (x-plane)
y_{dr}	radial distortion (y-plane)
x_{dt}	tangential distortion (x-plane)
y_{dt}	tangential distortion (y-plane)
x_i, y_i	coordinate for the i^{th} bounding box
x_{i+h}	forecast of i^{th} data
x, y	current coordinate
$\bar{x}, \bar{y}$	centroid coordinate
y_{init}	starting coordinate
Y_e	equalized Y channel

NAVIGASI PENGIKUT KENDERAAN BERASASKAN PENGLIHATAN MENGGUNAKAN PENGAWAL LOGIK FUZI

ABSTRAK

Kajian ini membentangkan pendekatan berasaskan visi untuk navigasi pengikut kenderaan darat. Sistem ini menggunakan pengawal logik fuzi untuk mengamudi secara berautonomi. Terdapat dua komponen untuk prototaip ini yang merupakan komponen sistem penglihatan dan komponen penggerak. Komponen sistem penglihatan dikawal oleh mikropemproses Raspberry Pi. Komponen penggerak pula dikawal oleh mikropengawal, Arduino Mega. Sistem penglihatan komponen menggunakan pengesanan Camshift dan pencahayaan tidak konsisten telah dibetulkan menggunakan histogram penyamaan. Parameter ini yang diperolehi daripada kajian rintis yang digunakan untuk mereka bentuk fungsi pengawal logik fuzi serta peraturan-peraturan yang sesuai. Terdapat dua kaedah peraturan fuzi yang diuji. Kaedah pertama iaitu kaedah A menggunakan 15 peraturan logik fuzi manakala kaedah kedua yang merupakan kaedah B memperkenalkan tiga peraturan nilai tambahan kepada 15 peraturan yang sedia ada. Keputusan kajian menunjukkan bahawa kedua-dua kaedah menghasilkan keputusan yang wajar kerana prototaip mampu untuk mengemudi sendiri untuk mengikuti kenderaan utama, dengan Kaedah B menghasilkan hasil yang terbaik.

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ABSTRACT

This research presents the vision-based approach to ground vehicle follower navigation. The system utilize fuzzy logic controller to navigate itself. There are two components of the prototype which is the vision system component and the actuating component. The vision system component is controlled by a microprocessor, Raspberry Pi. The actuating component is controlled by the microcontroller, Arduino Mega. The vision system component utilizes Camshift tracking and the illumination inconsistency is corrected using histogram equalization. The consequent parameters obtained from the pilot test is used to design the appropriate fuzzy membership functions and rules. The are two type of rules tested. The first one which is method A utilized 15 rules of fuzzy logics whereas the second method which is method B introduced three additional hedges rules to the existing 15 rules. The results show that both methods produce desirable results as the prototype is able to navigate itself to follow the lead vehicle with Method B produces the best results.

CHAPTER ONE

INTRODUCTION

1.1 Background

With the recent global alteration of economic emphasis towards Asia and the introduction of One Belt One Road initiative, there will be vast movement of goods and services which will jumpstart the initiation of a more efficient infrastructure networks within the Asian Region. The main transportation modes will nevertheless be sea route, rail and highways. Amid these common modes of transportation, the Asian Highway network is anticipated to play a significant role in the mobility of goods and personnel taking grasp of great production capacity of China, India and the up-and-coming economies around ASEAN countries. Example of One Belt One Road programme is the construction of new highways from China into Laos and Cambodia (Mooi, 2016).

Policies and issues related to the development of the Asian Highway and road transport continue to attract the interest of policymakers and experts attending legislative and expert group meetings and workshop organised by the secretariat. As a part of the initiative to achieve inclusive and sustainable development through regional cooperation and integration in transport in the Asia Pacific region several objective have been set:

(a) Establishment of road safety facility infrastructure standards

This objective emphasizes on *above the ground installations* which include road safety - such as acceleration and deceleration lanes, warning signs, regulatory signs and speed reduction devices and roadside safety features. User-friendliness aspect is highlighted in order to ease drivers' vehicle operations. For that purpose, the predictability of events should be implemented uniformly along the regions.

(b) Development of model intelligent transport systems deployment

Intelligent Transport System (ITS) is a combination of technologies based on the new capabilities offered by modern Information and Communications Technologies (ICT). The deployment of intelligent transport systems permits enhanced traffic management, more fluid traffic flows and higher levels of safety and security. Predictably intelligent transport systems can cope with traffic congestion , reduce traffic accidents and alleviate environmental externalities generated by road transport.

This project provides opportunity to study the experience of selected member countries (in this case Malaysia) in implementing intelligent transport system to improve road infrastructure management and operation. Also to promote the spread use of related technologies through the development of model intelligent transport system of the region.

1.2 Problem Statement

Road injuries and fatalities have been a growing concern in Malaysia. Statistics shows that more than 6,000 motoring fatalities are recorded each year (Pfordten, 2014). The number of death due to road accidents has also increased from 6,286 in 2003 to 6,917 in 2012 and it has been observed that car accidents had contributed to 22% of the total number of fatalities on the road in recent year (Abdul Rahman, 2013). Looking at the details of traffic crashes in 2012, about 23% of fatal crashes were related to speeding (Syed, Mohamed, Musa, Isah, & Wong, 2014). In urban driving environment accidents or collisions usually occur due to human errors such as misjudged distance, loss of control, poor manoeuvring and sudden braking. Drivers tend to misjudge the distance between their cars and the vehicles in front of them during heavy traffic such as rush hour or road congestion due to road works, resulting in collisions when the driver in the vehicles in front of them apply the brakes without warning.

With the rising number of road accidents and fatalities at local road networks, the Malaysian Government has recently announced the implementation of the Automated Awareness Safety System and Kejara Demerit Point System (Mooi, 2016). Observations show that significant progress in reducing road accidents occur in countries that adopt a multi-prong approach to tackling what WHO defines as the five pillars of road safety namely:

(a) road safety management

(b) safer roads

(c) safer vehicles

(d) safer road users

(e) post-crash response

While it is not feasible to address these five elements simultaneously, systems that are expected to be achieved on a short-term basis can only be safer vehicle; as those