DEVELOPMENT OF VOICE CONTROLLED DRIVE INTERFACE FOR CAR-LIKE MOBILE PLATFORM

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DEVELOPMENT OF VOICE CONTROLLED DRIVE INTERFACE FOR CAR LIKE MOBILE PLATFORM

By

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LIST OF SYMBOLS, ABBREVIATIONS & NOMENCLATURE

ϕ	front wheels curvature angle
$\circ$	degree
θ	gear angle rotation
Ω	ohm
%	percentage
A	ampere
A	area of the heat sink
Ah	ampere hour
cm	centimeter
h	heat transfer coefficient
kg	kilogram
KΩ	kilo-ohm
mH	mili-henry
mNm	mili-newton meter
$M\ s^{-1}$	meter per second
Nm	newton meter
nF	nano-farad
P_{tot}	maximum power
R_{jc}	junction-case thermal resistance
S	smallest gear angle rotation
T_{amb}	ambient temperature
T_{max}	maximum temperature
uF	micro-Farad
X_c	maximum horizontal displacement
V	volt
W	watt
ASR	Automated Speech Recognition

API	Application Programming Interface
CAD	Computer Aided Design
CAN	Controller Area Network
CLMP	Car-Like Mobile Platform
DC	Direct Current
DLL	Dynamic Linked Library
EMF	Electric and Magnetic Fields
HCI	Human–Computer Interaction
HMM	Hidden Markov Models
IC	Integrated Circuits
I/O	Input/Output
IMU	Inertia Measurement Unit
ITS	Intelligent Transportation Systems
LCD	Liquid Crystal Display
OS	Operating System
PCB	Print Circuit Board
PIC	Peripheral Interface Controller
POR	Power-on Reset
PWM	Pulse Width Modulation
RAM	Random Access Memory
RPM	Rotation per Minute
SAPI	Speech Application Programming Interface
SDK	Software Development Kit
SPI	Serial Peripheral Interface Bus
TTS	Text to Speech
UART	Universal Asynchronous Receiver Transmitter
USART	Universal Synchronous Asynchronous Receiver Transmitter
USB	Universal Serial Bus
WDT	Watchdog

PEMBANGUNAN PEMACU KAWALAN SUARA UNTUK PLATFORM KERETA MUDAH ALIH

ABSTRAK

Sistem pengangkutan pintar (ITS) melibatkan projek-projek yang disasarkan bagi menyepadukan komunikasi moden dan teknologi maklumat ke dalam sistem pengurusan pengangkutan yang sedia wujud. Dalam projek ini, satu pendekatan kepada ITS untuk sebuah prototaip kenderaan asas dibentangkan. Satu daripada topik penyelidikan yang paling penting dalam bidang ini adalah rekabentuk dan pembangunan kaedah-kaedah gerak alih dan sistem telekomunikasi pintar untuk ITS. Suara merupakan satu daripada kaedah mudah untuk berinteraksi antara manusia dan kenderaan. Oleh itu, kami meneroka rekabentuk dan pembangunan satu prototaip platform mudah alih seperti kereta (CLMP) yang meyerupai kereta sebenar. Sistem pacuan untuk platform mudah alih ini diperbuat menggunakan motor pelangkah dwikutub untuk ketepatan pergerakan sisi dan menguf uk. Untuk kawalan suara, kami bangunkan satu aplikasi yang berupaya mempelajari dan mengenali arahan suara. Sumber rujukan yang boleh didapati dengan percuma tentang pengecaman suara yang menggunakan model Hidden Markov (HMM) telah diintegerasikan ke dalam aplikasi ini. Daripada ujian arahan suara, 8 patah perkataan telah dipilih untuk mewakili semua jenis pergerakan yang mungkin bagi CLMP. Komunikasi di antara aplikasi dan sistem pacuan telah dicapai dengan menggunakan komunikasi bersiri. Dalam fasa ujian, telah didapati bahawa CLMP sangat berkesan untuk semua arahan suara dan telah didapati patuh kepada pergerakan asas tidak holonomi. Idea sebenar aplikasi ini adalah untuk mewujudkan satu kaedah interaksi altenatif di antara kereta dan pengguna. Interaksi seperti ini sangat berguna dalam rangka kerja ITS yang direkabentuk khas untuk orang kurang upaya.

DEVELOPMENT OF VOICE CONTROLLED DRIVE INTERFACE FOR CAR-LIKE MOBILE PLATFORM

ABSTRACT

Intelligent Transportation Systems (ITS) involve projects that aim to integrate modern communication and information technology into existing transportation management systems. In this project, one approach to ITS for a prototype elementary vehicle is presented. One of the most important research topics in this field is the design and development of locomotion methods and intelligent communication systems for ITS. Voice is one of the convenient methods for interaction between humans and vehicles. Therefore, we explore the design and development of a prototype Car-Like Mobile Platform (CLMP) that mimics a real car. The design is rear wheels drive because it creates stable motion for calculation. The drive system for this mobile platform was developed using bipolar stepper motors for accurate lateral and horizontal movements. For the voice control, we developed an application that is able to learn and recognize voice commands. Freely available libraries on voice recognition using Hidden Markov Models (HMM) were integrated into the application. From the tested voice commands, 8 words were chosen to represent all possible types of motion for the CLMP. Communication between the interface and the drive system was achieved through serial communication. In the testing phase, it was found that the CLMP responded well to all given voice commands and conformed to standard non-holonomic behavior. The idea behind this application is to create an alternative form of interaction between car and user. Such an interaction can be very useful in the framework of an ITS designed for the handicapped.

CHAPTER 1

INTRODUCTION

1.1 Overview

Intelligent transportation is the leading technology to improve safety, security and efficiency of the nation's transportation system. The design and development of Intelligent Transportation Systems (ITS) focus on technologies that enhance safety, increase mobility and sustain the environment.

ITS involve research that aim to integrate modern communication and information technology into existing transportation management systems in order to optimize vehicle life, power efficiency, safety, interaction, locomotion and traffic in urbanized cities. The increase of accident, increasing amount of transportation vehicles and increasing urbanization create the need for ITS application.

In general, various types of ITS rely on radio services for communication and use specialized technologies. Fig. 1.1 shows the basic idea for ITS which include telematics and all types of communications in vehicles, between vehicles (like car-to-car), and between vehicles and fixed locations (like car-to-infrastructure). However, ITS are not restricted to road transport they also include the use of Information and Communication

Technologies (ICT) for rail, water and air transport, including navigation systems (European Telecommunications Standards Institute [ETSI], 2009).

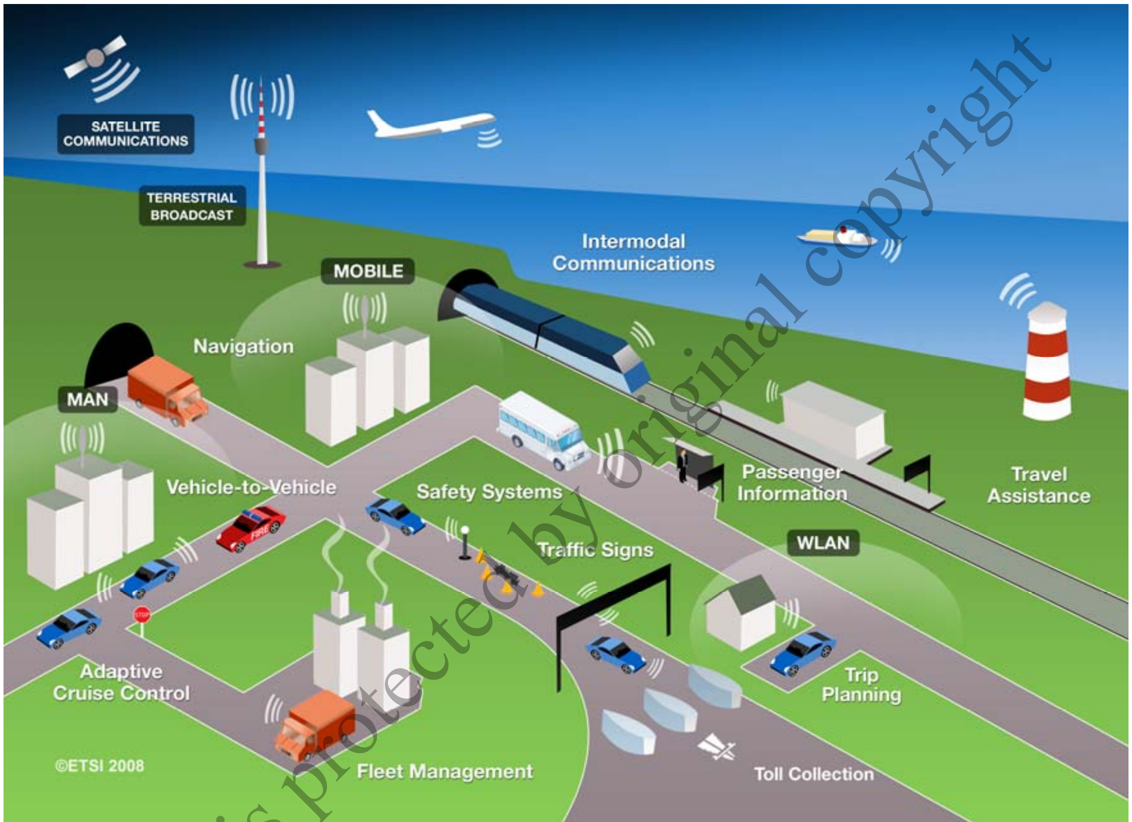

Figure 1.1: Basic idea of an ITS (ETSI, 2009).

1.2 Scope

There is a broad range of diverse technologies under the generic topic of ITS, that hold the answer to many of the transportation problems. In this research, one approach to ITS for an elementary vehicle is presented. One of the most important research topics in this field is the design and development of locomotion methods and intelligent communication systems for ITS. The main areas of concern here are the development of controllers for Human Computer Interaction (HCI).

HCI within the context of ITS is the study of interaction between people (users) and the decision making unit. It is often regarded as the intersection of computer science, behavioral sciences, design and several other fields of study. Interaction between users and decision making devices in an ITS occurs at the user interface (or simply interface), which includes both software and hardware. In this research, we limit and concentrate our study to voice as a convenient method to communicate between human and computer in a Car-Like Mobile Platform (CLMP).

1.3 Motivation

Voice command interfaces have successfully supplemented traditional man-machine command interfaces such as switches, keyboards and manual flight controls only in a few, relatively narrow application areas. Their limited presence to date is particularly puzzling given the long recognized and widely cited potential usefulness of the voice signals in everyday tasks such as controlling a machine or household appliance by simply telling it what to do. While voice-controlled systems would be a convenient item for the general population, for some handicapped clients it is a necessity. Traditional command interfaces, with their demand for visual acuity and motor dexterity, may be unusable and a voice signal maybe the only practical possibility, for personal control of lights, bed settings, television sets or other environmental factors.

Voice interface is also attractive in specialized tasks where available channel capacity using traditional man-machine interface channels has been exhausted and additional bandwidth is still needed. This is the case of an airline pilot or a CAD workstation operator whose fingers and eyes are already or fully engaged, or for remote actuation (for example voice phone dialing). Limited deployment of voice command devices has often been attributed to a lack of hardware products with sufficient power at acceptable price; however the last five years have seen advances in both regards without equally rapid expansion of applications (Yamamoto et al., 2008). The problem may change as much with the assumptions underlying design strategies as with the hardware implementing them. As such, it contributes toward building a general infrastructure for research into voice command applications, further benefiting society.

1.4 Problem Statement

The applications and the difficulty of voice-controlled interfaces, make it an interesting problem. In terms of applications, a voice-controlled interface is a device controlled by means of the human voice. By removing the need to use buttons, dials and switches, consumers can easily operate appliances with their hands full or while doing other tasks. The aim here is to have a portable, real-time, universal voice control system capable of operating in noisy environments, with a high level of accuracy and speed. The customer desires a hands-free unobtrusive device to capture the voices. The solution to this problem can be particularly interesting for the disabled.

This research attempts to design and develop a voice controlled drive interface. This interface is to be employed in a CLMP. The idea behind this application is to create an alternative form of interaction between car and user. Such an interaction can be very useful in the framework of an ITS designed for the handicapped. Within this context, designing a mobile platform that mimics the ability and capacity of a real car is becoming more and more of a necessity amongst researchers. Potentially, these kinds of platforms can be applied in many situations. This research presents solutions to this interesting application using state of the art hardware and software tools to meet a real and pressing human need.

1.5 Objective

The objective of this research is as follows.

- To design a mobile platform that mimics the ability and capacity of a real car (rear wheels drive type)
- To design and develop drive system (hardware) for Car-Like Mobile Platform (CLMP)
- Software design and development of drive system
- To develop Voice Interface Program
- Implementation of voice controlled method with mobile platform
- To perform integration testing between voice interface program and drive system

- Demo the voice controlled drive interface for a Car-Like Mobile Platform (CLMP) on the floor.

1.6 Methodology

In this section, a general methodology adopted in this research is provided. Details of these approaches are given in chapters 2, 3, 4 and 5. In general, this research can be divided into four stages.

In the first stage (chapter 2), a literature review has been done on mobile platform drive systems and voice interface systems. Existing applications are also presented. Mechanical architecture, electrical actuators, sensor technology, navigation strategies, voice recognition models, motion commands and programming languages are the main fields to consider in the development of a task specific voice controlled mobile platform.

In the second stage (chapter 3), the drive system for a CLMP is designed and developed. Various design parameters are used to select suitable actuators and electronic components for the drive system. These items are assembled on a PCB and their functionality tested and validated. Mobility and maneuverability of the platform plays an important role in the selection of elements or components.

In the third stage (chapter 4), a voice interface application is developed. This consists of developing a serial communication gateway and choosing a suitable mathematical model for speech recognition. The serial communication gateway will be part of a command controller while the mathematical model will be part of a voice controller. Both these controllers are software based. They were developed using advanced programming languages and some freely available libraries on voice recognition.

In the final stage (chapter 5) of this research work, the experimental setup and results for the implemented voice controlled drive system for a CLMP is performed. The obtained results from chapters 3 and 4 are firstly integrated to develop a CLMP. Then experiments are conducted to choose suitable English words to form the set of control commands. Finally, the chosen words are uses as motion commands for the CLMP and its performance tested and validated.

1.7 Expected Output

The main contribution of this thesis will be the design and development of a voice controlled drive interface. This includes the hardware design of a drive system for a CLMP and the software design of the command and voice controller. Various motion commands will be selected and their robustness tested against different users of various backgrounds. This will give us a dictionary of motion commands.

The designed application will be developed using an advance programming languages to achieve accurate and fast results. The coded applications and its functionality will be tested and validated. These applications should be executed on a readily available microcontroller or run under the standard Windows operating system environment on a normal laptop at a very good speed. These coded programs will be the second contribution.

1.8 Thesis Outline

The organization of this thesis largely follows the order in which the work was done, the scope and objective of the thesis is presented in this chapter. Chapter 2 reviews the available literature relating to mobile platform drive systems and voice interface systems. This chapter also describes some existing applications that have been developed using some of the most popular techniques and a critical analysis has been done on them. In addition, some performance evaluation is introduced to clarify how these methods are quantified amongst the different approaches using the most commonly used benchmarks. Chapter 3 presents the design, development and testing of the proposed drive system for the CLMP. This drive system is developed to obtain accurate position control. Besides this, the design is also adapted to emulate the non-holonomic motion of a real car. Chapter 4 concentrates on the software design and development, which is divided into 2 parts; command interface and voice interface. The entire system is integrated, tested and validated in chapter 5. The report ends with the conclusion in chapter 6 together with some future directions for this work.