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System for voice control of car modules communicating through CAN

Dimitar Stoimenov
Teacher Coordinator: Philip Petrov

Abstract

A system for voice control of car electronic modules is presented in the paper. Speech recognition of the driver voice commands is used. The system is based on duplicating the CAN messages and moving the relevant actuators as certain voice command is issued. The system can be configured for car models with different CAN network specifications. The system comprises a software implementation with intuitive user interface and flexible navigation as well as hardware components additionally installed in the car.

1 Introduction

As technology evolves more interesting and futuristic inventions and engineering solutions are designed and developed in some cases, created just for fun, while others created to facilitate and support. The perceptual human computer interfaces based on speech recognition are the core of the innovative ideas in that filed [1]. Once properly understood and recognized, spoken language can be used by a computer to perform various functions, complex tasks or even manage other devices and machines.
The increasingly widespread use of onboard computers and sophisticated networks in the automobiles allows for the implementation of various multifunctional smart systems. There are many cars with evoice control of the main functions produced by Bentley, Mercedes, BMW. The main disadvantage of these models are their cost makes them not available in mass production. There are many commercial systems for integrating a portable computer system in a car but most of them include only multimedia functions. They provide an opportunity to play music or surf the Internet using voice commands and speech recognition. Even if speech databases are developed for automotive industries [2-5] there is no complete universal system for car voice control able to perform rich control functions as moving windows, mirrors and seats or controlling other car modules with voice commands. The main purpose of such system is a safe driving since finding the buttons for different functions on the car's control panel can be very dangerous while the car is in motion.
A recent car models are equipped with an appropriate interface that can be used for computer based diagnostics. Through various service programs and complex protocols the systems in a car can be examined – either checking the values of certain sensors in real time or moving different executive parts of the car. These complex systems are mostly intended for workshops, diagnostics and repair.

The system suggested in the paper is aimed at voice control of rich set of car's functions. The system is designed to be readily available for a wide range of users. It provides easy connection to the car network and possibility to set voice commands for certain functions according to the user's preferences. The suggested solution uses simplified interface and handling functions as well as using functions of modules already programmed and configured in a car.
The suggested voice control system uses the functionality of the control units programmed by the car's manufacturers. The CAN bus messages are used to activate the executive units or to read the values of certain sensors by the developed system in order to control the car's modules and to add new functionality to the existing CAN network.

2 Controller Area Network (CAN) system and Voice Control Engine

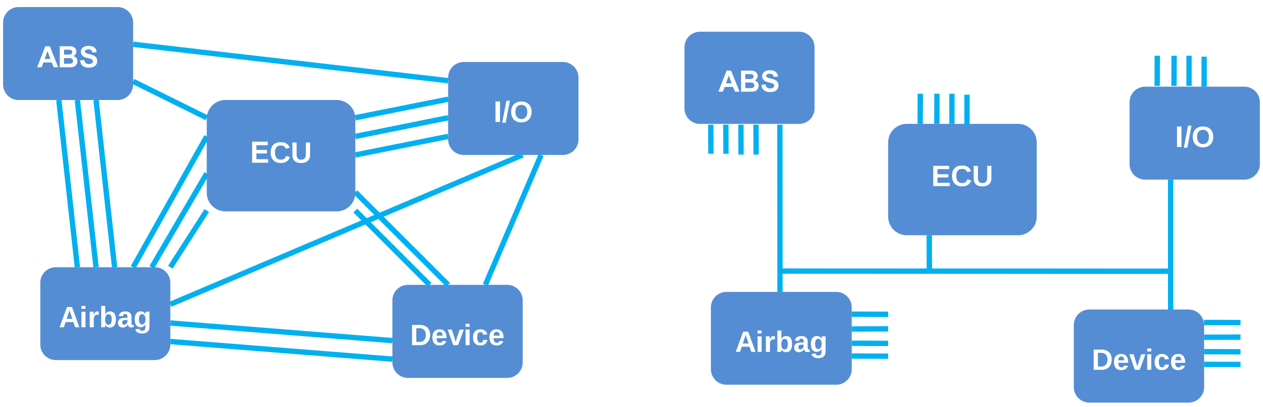
2.1 CAN

2.1.1 Connection

System uses direct connection to the CAN bus of the car. It can receive all messages and transmit different messages when detects a spoken command. The CAN bus is message oriented communication standard and therefore the control units in the car listens all the messages important for them and are not interested about the sender. Thus messages from the already installed units can be copied and functions of the control modules can be duplicated by a human voice commands.

2.1.2 CAN in automotive applications

Controller Area Network is the leading network in power-train and body electronic applications and it is very well accepted by car production companies [7]. One of the biggest car development companies – DaimlerChrysler, Ford and General Motors, are intensively involved in CAN network developments [6]. The difference of car systems with or without a CAN bus is shown on fig.1.



(a) (b)

Fig. 1 Differences between systems organized without (a) and with (b) CAN bus.

2.1.3 Basic organization of electronic units in a vehicle

The CAN bus connects the individual control modules and allows them to exchange information. Sensors are connected to the analog inputs of the control modules as well as various buttons or potentiometers can be connected to analog inputs. Signals from the sensors and controls are transferred to the closest control unit, and then converted into digital format and send in the form of coded messages to the bus. Each control unit can filter such messages, decode information from sensors and decide when and how to send analog signal to the actuator, controlled by it. (fig.2).

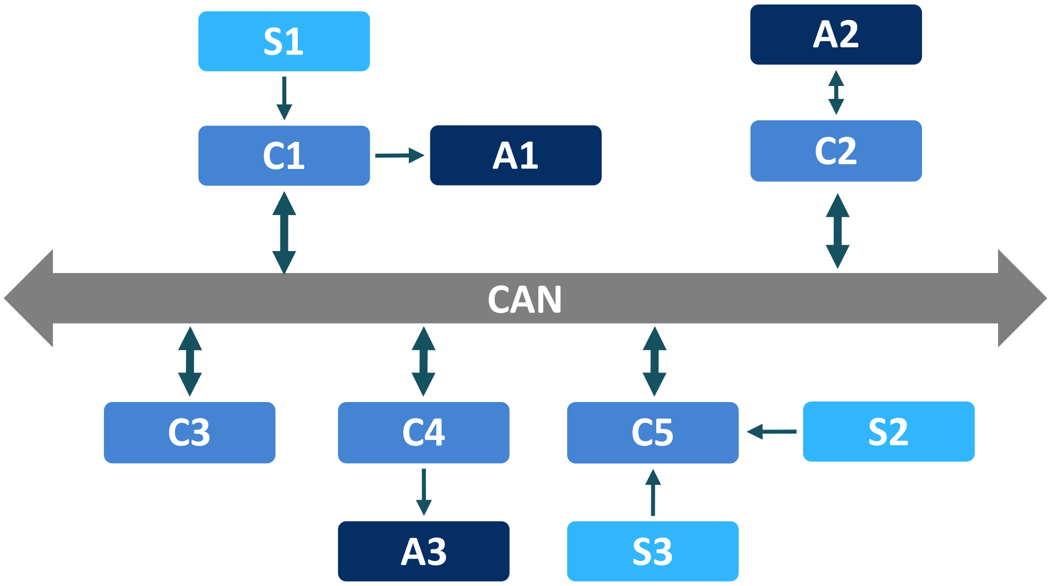


Fig. 2. Principle scheme of CAN related control units in a vehicle.
C – control unit, A – actuator, S – sensor, button.

Four groups of control units can be distinguished in CAN system:

-Control units with activation functions (eg. K3, K5): They are instructed to monitor messages from the bus and if needed to trigger a mechanism. The connection between them and executive mechanisms can be in both directions - then they follow the actual position of the actuator (eg. K3).

-Control modules with sensing functions (eg. K6): Their task is merely to transmit to the bus information about the value of the sensors or the state of buttons connected.

-Control modules with complex functions (eg. K1): Can perform the functions of the two control modules mentioned above. Most of the control units in automobiles are that kind. They do a lot of work at the same time and can handle a lot of data.

-Control modules with management functions (eg. K4): They don't have analog inputs and outputs, but are connected to the bus and depending on how they are programmed, communicate with other modules and transmit messages. Such modules can be used for central gateway between different CAN buses in the car or between cars and diagnostic equipment (like CGW - Central Gateway Module in new models of Mercedes). [8]

An example is given on fig.3 with a simple situation, where by pressing a button in the left front door - S20/1, an actuator move right back window up or down – M10/6. The task is performed in the following steps:

- pressing the button S20/1s4;

- control module in left front door – N69/1, sends a message by the CAN for pressed button S20/1s4;

- the message reaches all the control unites associated with CAN bus;

- control unit N69/4 in the right back door receives the message and activates the actuator for moving the right back window M10/6;

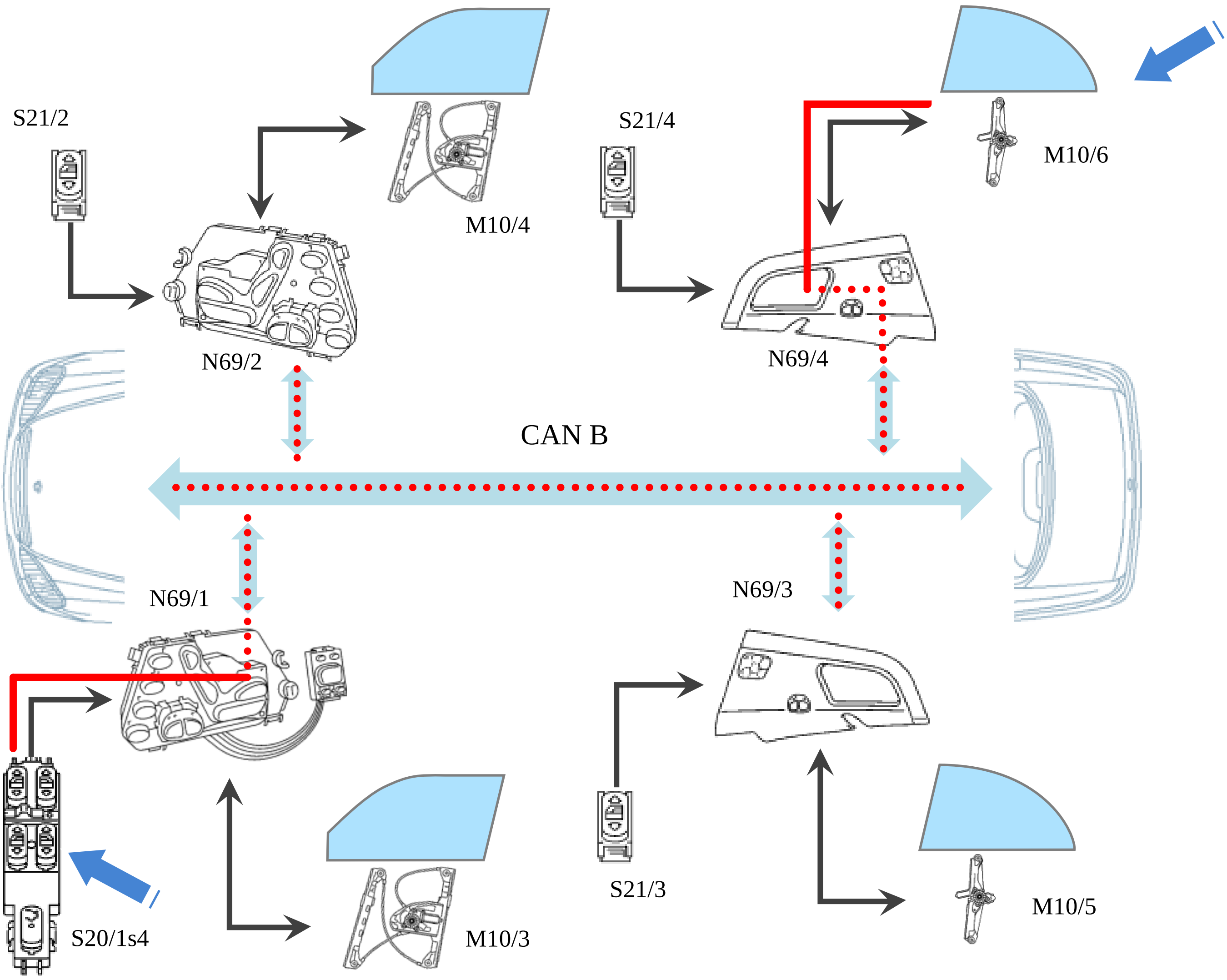


Fig. 3 Moving right back window in a vehicle [8]

2.2 Voice control and speech generator

2.2.1 Speech Recognition Engine

The voice control is a very flexible for control of devices; however not enough “trusted” way to control computer components. Different background noises or change in the human mood may disrupt the voice recognition making it impossible for the computer to parse the command. Therefore a very careful examination on what components of the car exactly can be controlled with voice must be made [3, 4].

For advanced speech capabilities, Microsoft provides native and managed interfaces for developing speech-enabled applications: a COM-based Microsoft Speech API (SAPI) and the .NET Framework 3.0 System.Speech* namespaces. SAPI is middleware that provides an API and a device driver interface (DDI) for speech engines to implement. The speech engines are either speech recognizers or synthesizers. Can be installed different engines for different languages. Although this is opaque to developers, the managed System.Speech* namespace communicates to these engines both directly and indirectly by calling through SAPI (Sapi.dll). Windows Vista supplies default recognition and synthesis speech engines, but this architecture enables plugging in additional ones without changes to applications. Each speech engine is language specific. The System.Speech namespaces are largely built upon and follow the general programming approaches of SAPI 5.3. These namespaces can be used to speech-enable console, Windows Forms, and Windows Presentation Foundation applications. To use this set of managed libraries, a reference to the System.Speech.dll assembly must be added to the project. The speech namespaces include some capabilities not found in SAPI 5.3, including a grammar builder (GrammarBuilder), prompt builder (PromptBuilder), an SRGS document object model (SrgsDocument), and strongly-typed grammars.

2.2.2 Text to speech synthesiser

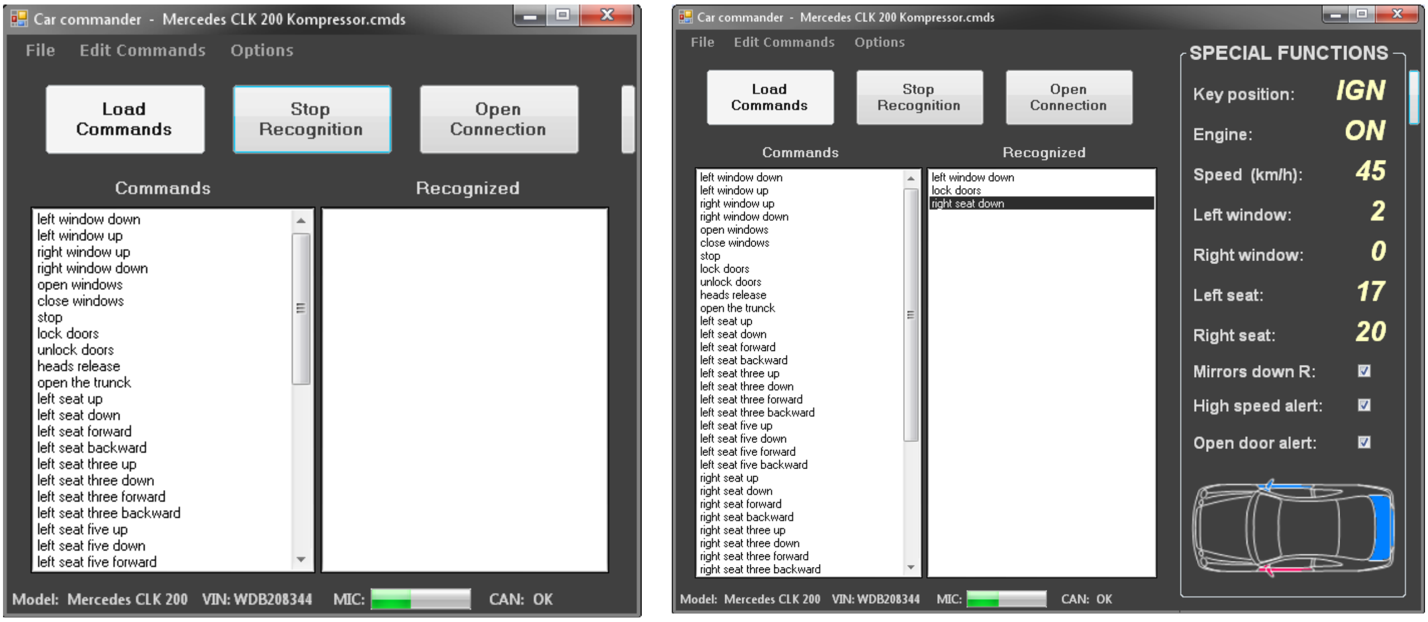
For generating answers of the computer Text to Speech technology (TTS) is used. The computer interacts with the user and responds to the pronounced command or to certain situations. TTS allows applications to stream text from virtually any source for conversion to an audio format. Thus pre-record information for storage as sound files is not required. Also, presenting dynamic data using TTS is one of the deployment approached of speech applications. Some vendors provide TTS with human-like quality and thus speech applications can substitute TTS for voice talents where prompts are used to direct callers. This level of quality presents an opportunity for a rich user interface for speech applications in general. With TTS users can configure the answers of the system as desired.

2.3 System architecture

2.3.1 User interface

The suggested system for voice control in car using CAN is developed as software system wuth separated user and administrative interfaces. The user interface is shown on fig. 4. The simple and easy to use interface provides possibility the system to be used even on small portable computers with touch screen. A functionality to load commands provides an option to load the preferences file and thus move the system from one car to another by only loading car-specific voice commands. The voice recognition mode is enabled either by pressing a button on the user’s interface or to avoid distraction specific hardware button can be mounted in the car. Additional option is provided by the user’s interface to establish the connection with the CAN network.

More details from the CAN bus can be monitored and updated in real time (fig.4-b) such as mirrors and seats positions, current speed and engine status.

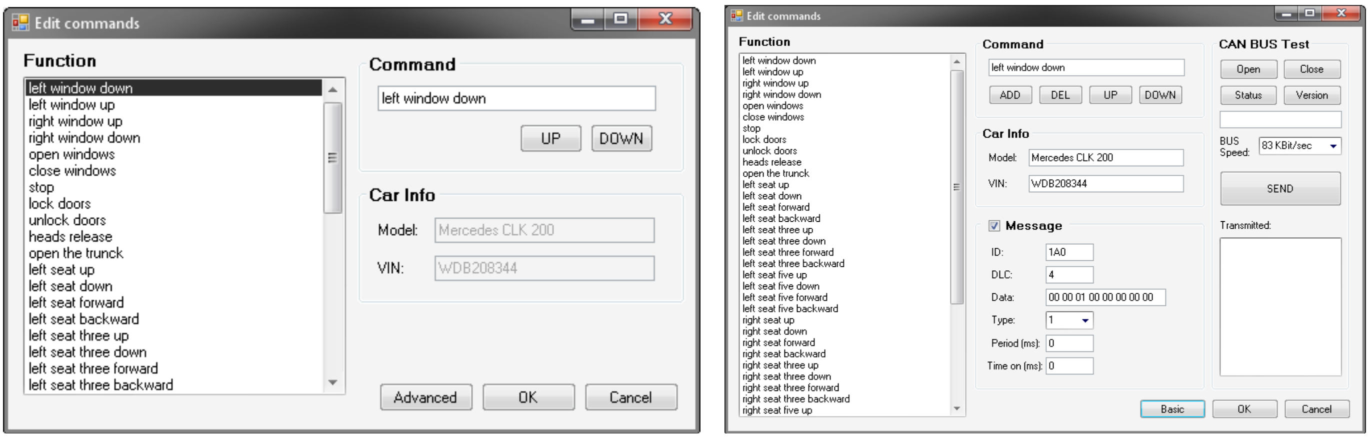


(a) (b)

Fig. 4 User interface. (a) – basic, (b) – extended.

2.3.2 Administrative interface

The administrative interface is shown on fig. 5 and provides options for adding, deleting and editing voice commands from the configuration files. An advanced mode is also provided in the administrative panel given the option to add completely new car features which are not yet recognized and are still not added to the software system.



(a) (b)

Fig.5 Administrative interface. (a) – basic, (b) – advanced.

Using the advanced mode the system is “sniffing” the current CAN network traffic in order to allow new features to be recorded and voice commands to be added accordingly. This makes the system well portable between different car models. Every voice command for a specific function is customizable and can be changed according to the user preferences and requirements.

2.4 Adding special features to the car functions

The developed system uses actual values from different units and depending on their values it controls actuators or carry out other functions. Additionally new features are also suggested and provided by the voice control system:

1. "Mirrors down R" – moving mirrors down when reversing. In reverse gear the system sends a signal to left and right door control modules for the movement of mirrors in a downward direction for 2 seconds. This gives the driver good view to the rear wheels and make parking easier. In exclusion of reverse gear the system automatically returns both mirrors in their previous state. (actual value – the position of gear selector; controlled units – left and right door);

2. "High speed alert" – a warning for speeding. Computer - synthesized voice alerts the driver that the speed is increasing. The maximum allowed speed before the alert message is not adjustable at the moment. Future system extension will use connection to a GPS receiver and real time update of the maximum speed. The warning is repeated every 15 seconds. (actual value – vehicle speed; function – voice warning);

3. "Open door alert" – warning for an opened door. Computer synthesized voice alerts the driver for an open door if speed is bigger than 10mph. (actual value - speed and doors knobs, function - voice warning).

3 Results and analysis

The suggested voice control system was implemented and installed on Mercedes CLK 200 year 2001 – a car without any stock voice recognition capabilities. All the experiments show that the voice commands of car devices provide flexible and comfortable features which may bring the hands free driving at further level. The fully functional system uses a microphone, a button to enable voice commands, a notebook and a CAN adapter (fig.6).

(a) (b) (c)

Fig.6 System components (a) – microphone, (b) – button, (c) – notebook.

4 Conclusion

The versatility of the system depends on the opportunities provided by the target vehicle. Automobile manufacturers organize different CAN communications in different cars. The

suggested voice control system allows for duplication of functions of the modules in the car such as moving windows, seats and mirrors in all directions, opening the trunk, locking and unlocking the doors.
Future extension of the system will connect a GPS receiver and based on data received maximum allowed speed will be dynamically determined or a destination will be selected through voice commands. Another possibility is adding a module for manipulating multimedia car features as for example start music player with a voice commands. Loading command dictionaries will allow desired track to be searched and automatically played using speech recognition of the voice command.
The system can be developed for smart phones or pads and the connection with the car can be made via bluetooth. This eases the user and make it possible to use the system immediately after entering the car. The app on the smart phone can communicate with the car by an OBD2 Blue tooth dongle, and send CAN messages. Using of only one adapter for the car and heands free for the smart phone will make the installation of the system very easy and every user can set it by himself.
Further system extension will be the development of electric circuit for USB based communication with the program. In this way even the car modules not related to the CAN bus will be controlled thus making the suggested solution available in automobile without CAN network.

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DIMITAR STOIMENOV
Technical University of Sofia
Computer systems and technologies
BULGARIA
E-mail: dimitar.ns@gmail.com