SER 593: Applied Project
Human Car Interaction
Report

By:

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1. Abstract

Cars have become complex interactive systems. It is common that drivers operate a vehicle and, at the same time, interact with a variety of devices and applications. Texting while driving, looking up an address for the navigation system, and taking a phone call are just some common examples that add value for the driver, but also increase the risk of driving. In the recent past, there have been many new technological opportunities for designing useful and attractive in-car user interfaces. With technologies that assist the user in driving, such as assistive cruise control and lane keeping, the user interface is essential to the way people perceive the driving experience. In this modern age, there is a lot at stake in the automotive industry. Pursuing a "trial and error" approach is not acceptable as the cost of failure may be fatal. User interface design in the automotive domain is relevant across many areas ranging from primary driving control, to assisted functions, to navigation, information services, entertainment and games.

2. Introduction

Driving is already a complex task that demands a varying level of cognitive and physical load.With the advancement in technology, the car has become a place for media consumption, a communications center and an interconnected workplace. The number of features in a car has also increased. As a result, the user interaction inside the car has become overcrowded and more complex.Cars are moving beyond the means of transport for people and are viewed by many people as personal spaces.A significant amount of time is spent by people in cars while commuting to work and therefore its becomes an industry that needs to evolve everyday.In addtiond to the increased functionalities that are being preffered by manufacturers today,cars have also become a place for information access,media,communicationd and leisure.The technology in the car is digital and as a result cars have become interactive over a period of time.A major part is played by humans who interact with cars and therefore they play a pivotal role in the design and the user experience.

In recent years several new trends have emerged that have severe implications on driving and the user experience in the car:

- Most significant is the use of Mobile devices while driving.
- Increased interaction with the infotainment system of the car.
- Interaction with smart and autonomous functions in the car.

Through this applied project, we hope to bring together current researches in HCI to discuss both the needs for improved and innovative interaction and interfaces in the car, and techniques for achieving these.

3. Experiment

3.1 Statement of the problem:

Is it good to keep the user interface screen at the bottom or at the top of the center stack screen holder? To get an answer to the above question, we designed our first experiment to compare the different positions of the interactive interface and evaluate its impact on the response time from the driver.

3.2 Hypothesis:

Null Hypothesis:

Position of the interactive interface screen has no effect on response time in using the interface

Alternative Hypothesis:

Position of the interactive interface screen has an effect on response time in using the interface

3.3 Variables:

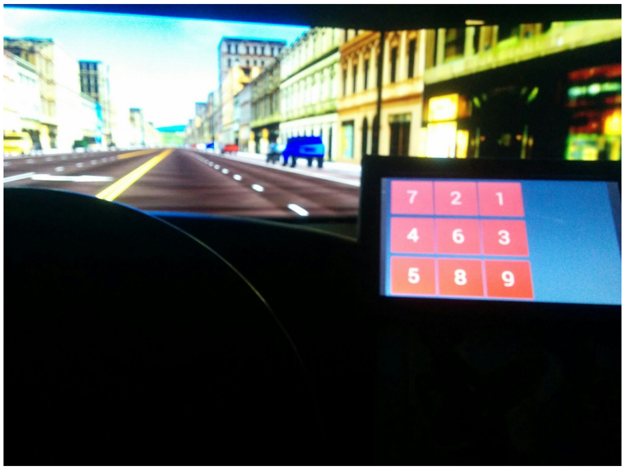
Independent Variable: Touch on the screen
Dependent Variable: Response time taken to complete a set of instructions.

3.4 Setup:

A web application was developed to display the user interface. The developed application was tested on Android v4.4.2 based Samsung Galaxy Tab4 8.0 using Dolphin HD web browser.

The Dashboard Simulator was used for this experiment. The volunteers were asked to drive on a previously programmed route and were given special instructions.The following conventions have been used throughout the experiment:

1. Top of the center stack: An android tablet with a 10” (inch) screen is placed on the top of the center stack.



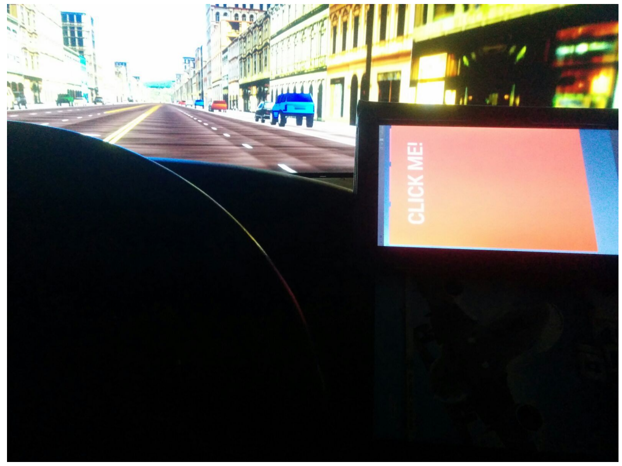


Figure 1. Top of the center stack **Figure 2. Top of the center stack Popup**

2. Bottom of the center stack: An android tablet with a 10” (inch) screen is placed on the bottom of the center stack.

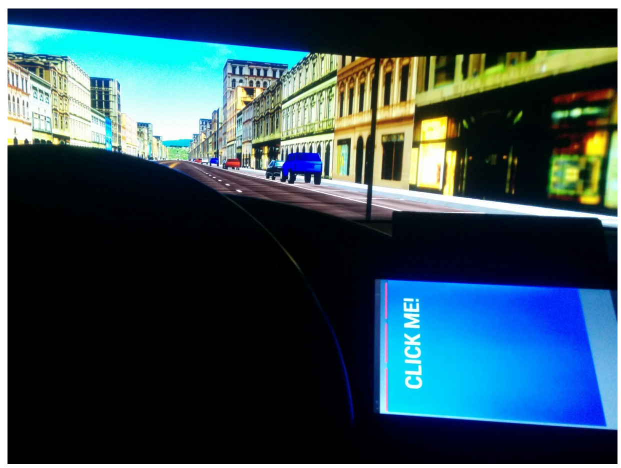


Figure 3. Bottom of the center stack **Figure 4. Bottom of the center stack Popup**

3) Reaction time (in milliseconds): The application measures this metric automatically and the unit of measurement is in milliseconds.The reaction time is considered as the amount of time a driver takes to complete a set of operations. The Driver is asked to click the icons in a certain order on the screen while driving under the normal conditions. The time taken to click all the icons beginning from the first click registered is noted as the reaction time. The greater the reaction time, the higher the distraction. Also, any deviation in those readings without other modifications in the experiment should indicate distraction occurrence.

3.5 Steps of Execution:

There were a total of 52 number of participants in this experiment. Each participant was first given a "test" drive of the simulator, to get him/her accustomed to it.

Once everyone had completed their test drives, each participant was asked to drive the same route twice, each time with the user interface screen being placed in different positions. Please note the user interface screen was both in the secondary and tertiary site for the driver.

The instructions were as below:

1. While performing the primary task of driving , the driver was asked to touch the buttons in order at three locations on the route :

Button Sequence	Location
451	Very first left turn when the cars would be coming from different directions
396	When the cars suddenly change on the freeway
278	On the last left turn of the simulation when the cars bump into each other on the side

Steps of Execution:Button Sequences

2. The number sequence on the user interface is automatically randomized to prevent learning effect amongst participants.

3. The user interface screen will be in landscape mode for the top and bottom positions.

4. A sudden coloured message pop up comes in the tertiary site of the driver “Click Me” just before the driver meets pedestrians on the way to check his attention on the road and thus to measure his response time of switching delays between the primary and the secondary task time.

During the execution of each task, the time taken by the the user interface screen to respond was measured and tabulated for each subject.

3.6 Results:

Out of the 52 participants, 6 participants were not able to complete the tasks in the experiment successfully and therefore we considered the results of only 46 participants. These were the aggregated results of the response time for each of the button sequences, popups. We also show the average time taken. (See Appendix A for raw participant data)

	Placement	451	396	278	Popup	Total
Total Time	Up	167541	163750	152133	375252	784848
	Down	209915	168545	180379	442671	1001510
Average Time	Up	3642.196	3559.783	3307.239	8157.652	**17061.91**
	Down	4563.37	3664.022	3921.283	9623.283	**21771.96**

Table 1. Response Times(in milliseconds)

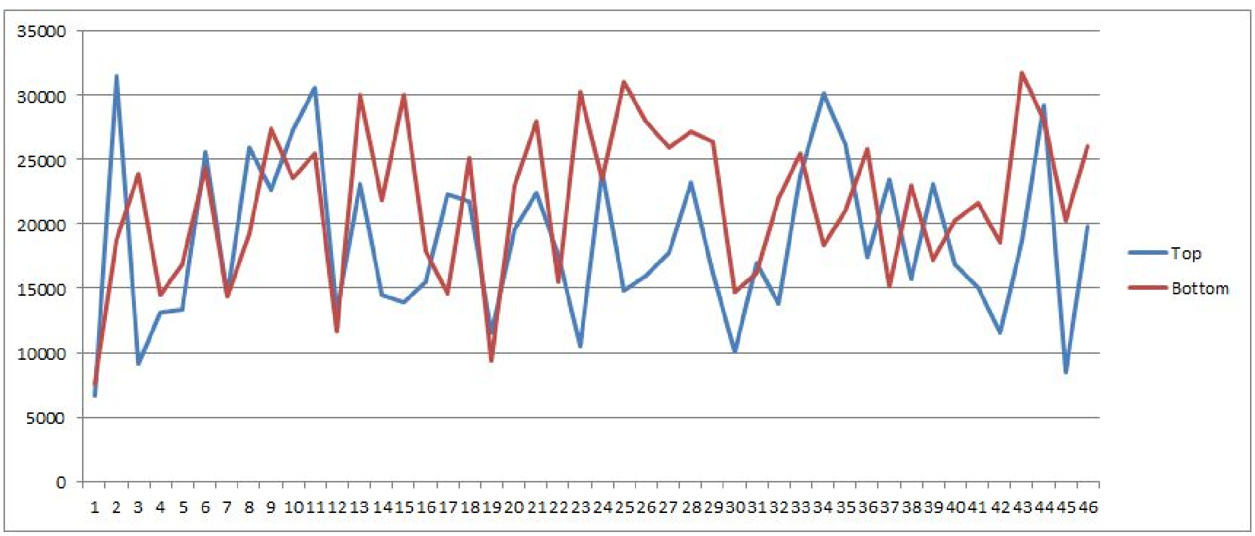


Figure 1. Total Response Time for all 46 participants(in milliseconds)

3.7 Conclusion:

The total average time for "Center Stack Up" position is **17061.91 ms** and for "Center Stack Bottom" position is **21771.96 ms** which shows that the Top position has much faster response time on average.

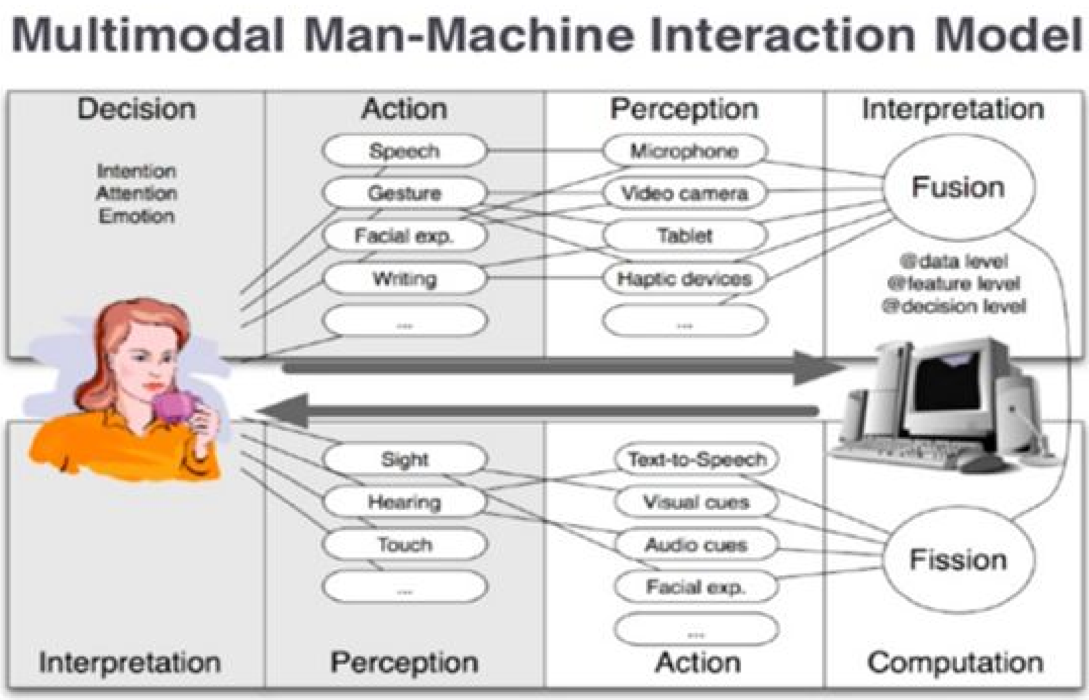
This proves the hypothesis that the position of the interactive interface screen has an effect on response time in using the interface.

4. Literature Review

4.1 Multimodal Interaction

Overview

Multimodal Interaction is a situation where the user is provided with multiple modes for interacting with the system. Multi-modal systems as those that process two or more combined user input modes such as speech, touch, visual and learning in a coordinated manner with multimedia system output.



Sequential Multimodal: means user will have to switch between the modes of interaction but cannot use the modes together.

Simultaneous Multimodal: allows user to use more than one mode at a time to interact with the system. For example: in route finder application the user could say “Show me the quickest route from here and here” while indicating the two locations on an on-screen map using touch.

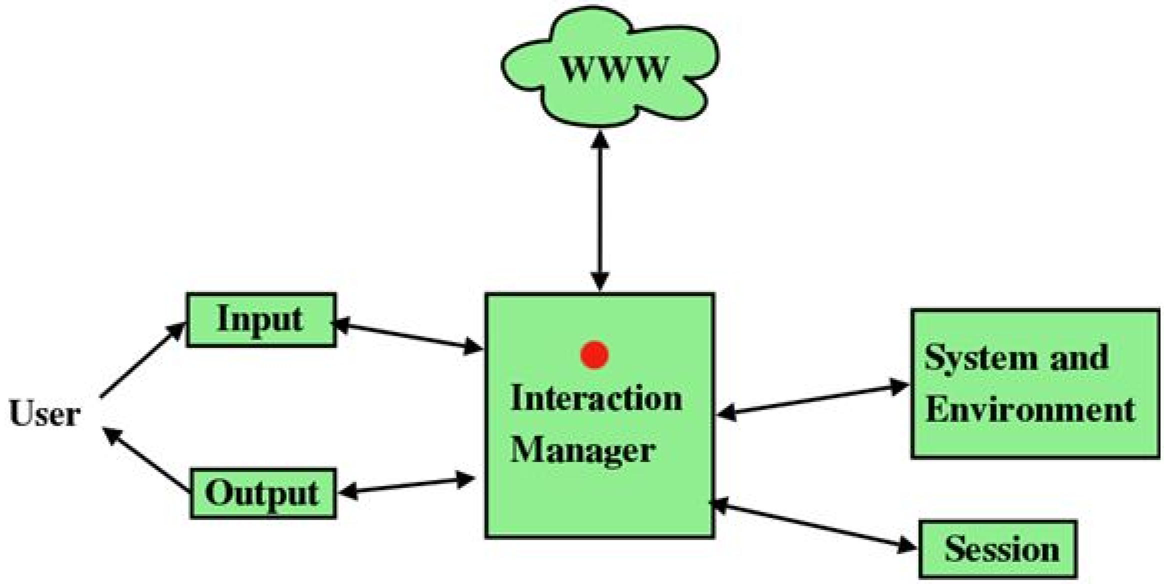
Fusion of inputs from multiple modals uses strengths of one mode to compensate for weaknesses of others like design time and run time.

General Requirements of MMI Interfaces:

- Supplementary and complementary use of different modalities
- Seamless synchronization of modalities
- Multilingual support
- Easy to implement
- Accessibility
- Security and privacy
- Delivery and context
- Navigation specification

Input/ Output Modes:

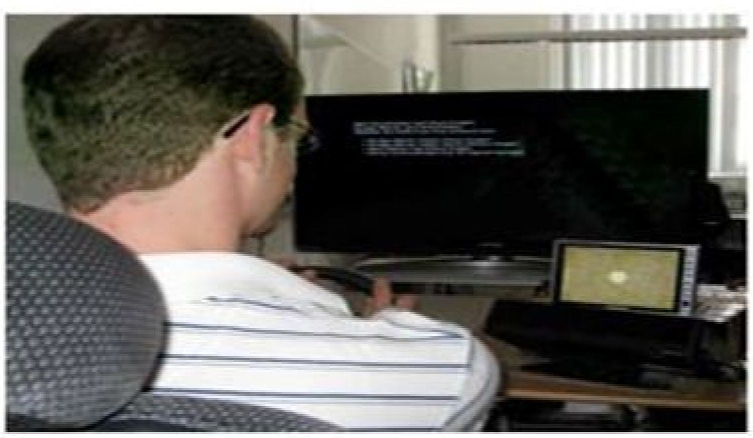
Multimodal interaction revolves around having certain modes which take the various forms of input, combine them seamlessly, process and give the feedback or output in one or the other output modes.



Input Modes

Visual:

Visual interaction is implicit interaction which can help automotive UIs to better support attention switching and interaction. Depending on the position, the effort to locate an input element or to direct the view to the screen differs. Camera and sensor are also part of the visual input.



Speech:

Audio input is taken from the user. The words are recognized by using a speech recognition technique. Speech is used to select and qualify one or multiple objects (e.g., “window”) and their function (e.g., “open”) to be manipulated.

Touch:

Using a simple touch gesture, the interaction style lowers the visual demand and provides at the same time immediate feedback and easy means for undoing actions. After the selection of the interaction object(s) and function, the user can perform a gesture to complete the intended action. This form of interaction (e.g. moving a finger up and down on a touchpad) allows for a fine-grained manipulation.

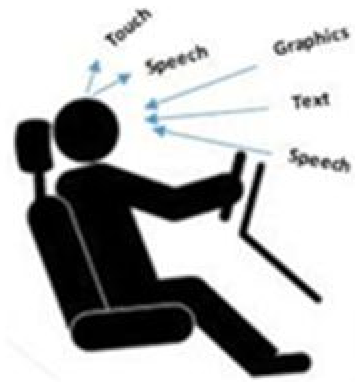
Output Modes

Text:

The output or the feedback is displayed as a text message or prompt to the user. This leads to a bit of distraction and not recommended as a standalone mode of output.

Audio:

Voice prompts are part of this output mode. Usually they are short affirmations for any speech commands issued by the user, or warnings and alerts when an issue arises.



Learning:

Learning mode involves two sub modes called "Learning Text" which allows user to get trained with regards to placement of icons and recognizing every icon by sight. Below every icon is a one word descriptive text that will give the user an idea of what the icon does and the command used in speech recognition. And "Learning Voice" allows user to get trained with respect to the multimodal functionality and experiencing less cognitive challenge. For example: The user said play track 15 by Enrique but this command is not acceptable by the dialogue system but system will check all possible options and will speak back to the user. IF user touches any icon then system will echo the speech command corresponding to that icon. This way user will get to learn the commands. This mode can be turned on and off as per the user convenience.

Challenges and Opportunities

Challenges in MMI:

Despite the significant progress on multimodal interaction systems in recent years, much work remains to be done before sophisticated multimodal interaction becomes a commonplace, indispensable part of computing.

Multimodal input Integration:

One of the biggest challenges is multimodal integration methods and architectures need to explore a wider range of methods and modality combinations. User's actions or commands produce multimodal inputs, which have to be interpreted by the system. It is obtained by merging information that is conveyed via several modalities by considering the different types of cooperation between several modalities. An ambiguity arises when more than one interpretation of input is possible. So Problem and contradiction occurs between various inputs. . Modalities with very different characteristics – e.g., speech and eye gaze, facial expression and haptics input, touch-based gesture and prosody-based affect – may not have obvious points of similarity and straightforward ways to connect.

Security and Privacy Issues:

Electronic security is one of the major concerns for all the people. Hackers, dissatisfied employees, anti-social element organizations may target automated vehicles and intelligence systems resulting in traffic concerns and accidents.

GPS Spoofing can also be done which leads to false destinations and lead to kidnapping. Privacy is one of the basic rights and not a privilege. Thus, it is the primary responsibility to ensure that the input received in cars does not violate privacy of an individual.

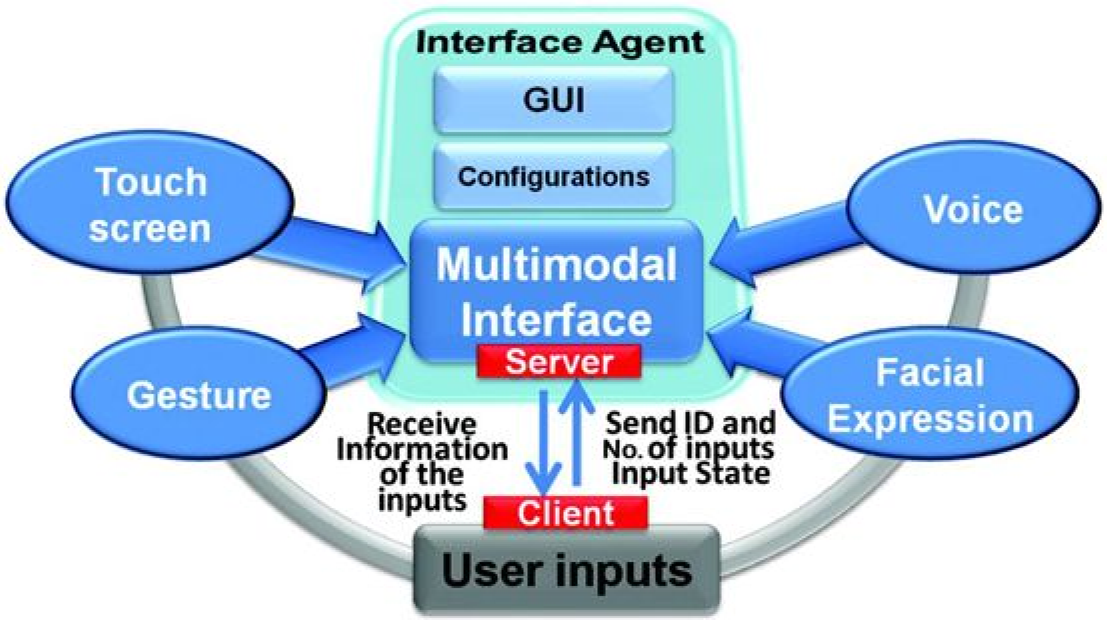
Opportunities in MMI:

Multimodal interaction has a number of opportunities to be used in various applications because:

- Provides transparent, flexible, and powerfully expressive means of HCI.
- Easier to learn and use.
- Robustness and Stability.
- If used as front-ends to sophisticated application systems, conducting HCI in modes all users are familiar with, then the cost of training users would be reduced.
- Potentially user, task and environment adaptive.
- Support shorter and simpler speech utterances than a speech-only interface,

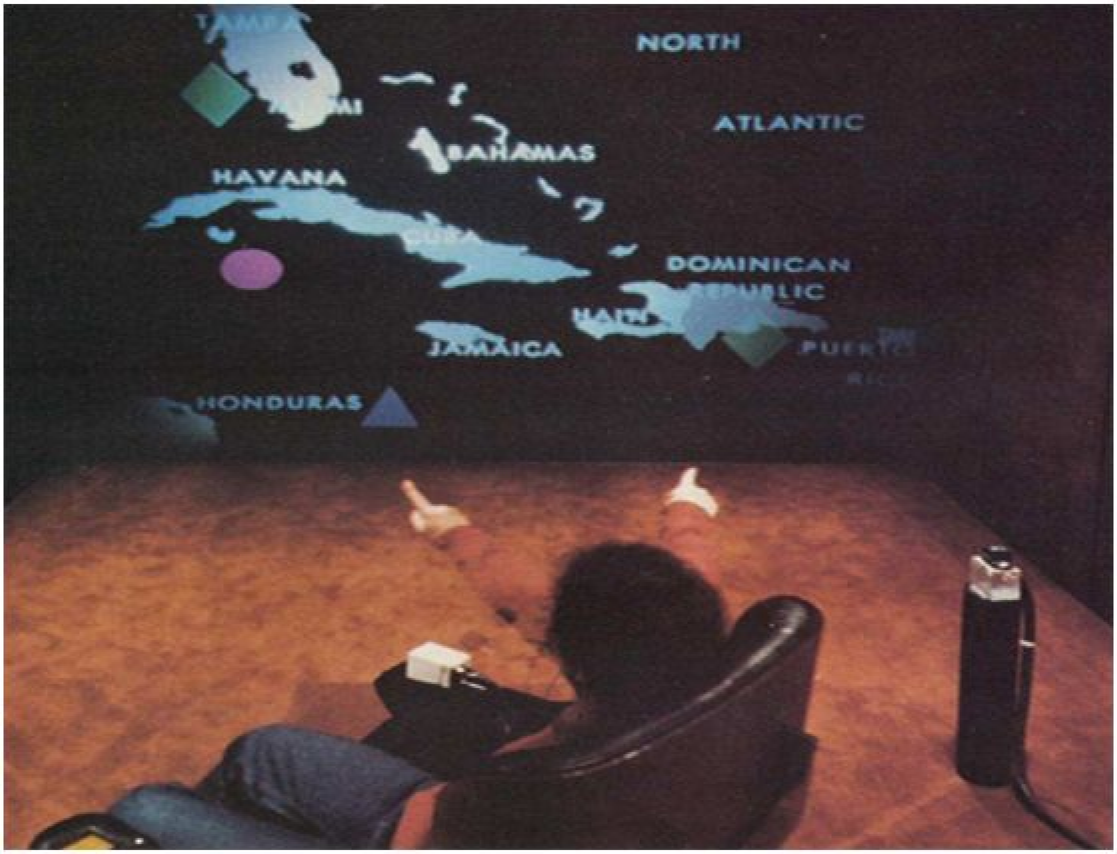
Multimodal In-Car Enhanced Interaction System:

Workload and distraction suggest that increasing the complexity of a speech-based interface may impose a greater cognitive load. Multimodal interfaces are recognized to be inherently flexible, and to provide an especially ideal interface for accommodating both the changing demands encountered during mobile use and also the large individual differences present in the population. Multimodal provides the necessary advantages and reduces driver load and distraction.



Put-that-there:

"Put That There" is a voice and gesture interactive system implemented at the Architecture Machine Group at MIT. It allows a user to build and modify a graphical database on a large format video display. The goal of the research is a simple, conversational interface to sophisticated computer interaction. Natural language and gestures are used, while speech output allows the system to query the user on ambiguous input. This project starts from the assumption that speech recognition hardware will never be 100% accurate, and explores other techniques to increase the usefulness (i.e., the "effective accuracy") of such a system.



Future Of MMI:

- One important future direction will be the development of blended multimodal interfaces that combine both passive and active modes.
- Mobile map-based systems and systems for safety-critical medical and military applications.
- In biometrics research, which combines recognition of multiple behavioral input modes (e.g., voice, handwriting) with physiological ones (e.g., retinal scans, fingerprints) to achieve reliable person identification and verification in challenging field conditions.

4.2. Driver Distraction

4.2.1 What is Distracted Driving?

Involves any non-driving activity a person engages in that has the potential to distract him or her from the primary task of driving and increase the risk of a crash.There are three important aspects of the problem – the source of the distraction, its effects on driving behavior, and the potential consequences.According to Centers for Disease Control and Prevention

"Each day in the United States, more than 9 people are killed and more than 1,060 people are injured in crashes that are reported to involve a distracted driver"

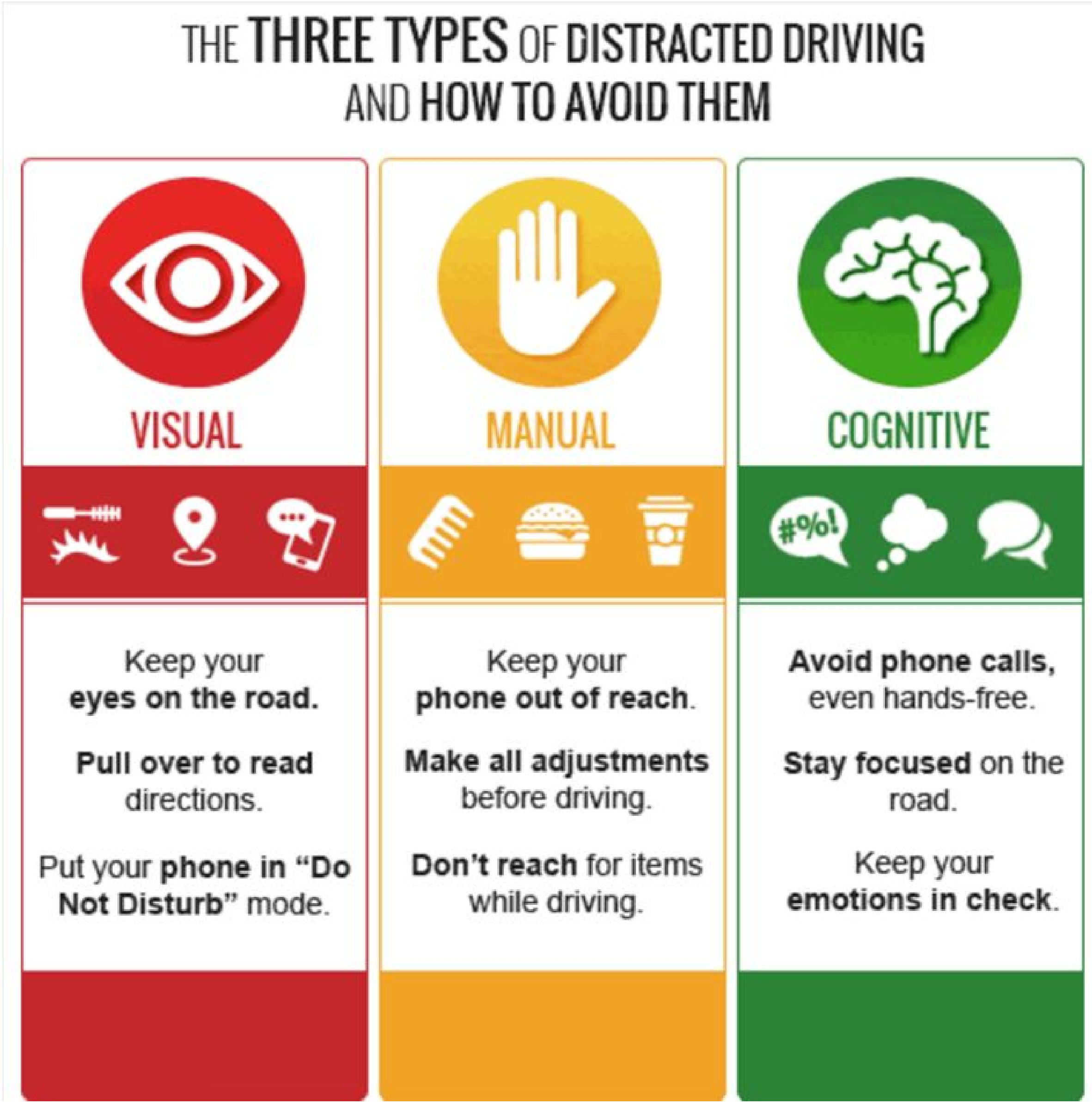
4.2.2 Types of Distraction

There are three main types of Driver Distraction

- **Visual** – Tasks that require the driver to look away from the roadway to visually obtain information.Visual distraction means taking eye off the road and eyeing at something else either inside the car or outside the car. This category of the distraction is very common, as a driver it's boring to keep gazing only on the road all the time but taking the eyes off the road for very long time is also very risky. The visual distraction mainly comprises of either secondary or tertiary task. Visual distraction often happens while searching a functionality in the center console. The observations noted by in-vehicle equipment show that almost 80% of all crashes and 65% of all near-crashes involved the driver looking away from the roadway just prior to the event, Cognitive model suggests that the more we are acquainted with the interface and knowledgeable the less cognitive load it require to do the task related to that interface. It means the novice drivers are more inclined to dangerous distractions. A data collected from recording devices installed in participants' vehicles from 2003-04 (experienced drivers – average age 36.2) and 2006-08 (novice drivers – average age 16.4) measured the risk factor of actual crashes and near-crashes related to performance of the tasks including reaching for cell phone, dialing cell phone, talking on cell phone, texting, reaching for other objects, eating or drinking and adjusting vehicle controls.
- **Manual** – Tasks that require the driver to take a hand off the steering wheel and manipulate a device.Physical distraction means diversion or physical movement with one or both hands away from the steering wheel, and turning back or side. This category of distraction is most common

and most often observed in-vehicle distraction. It includes task moving one or both the hands away from steer wheel for the different tertiary tasks, like texting while driving, manual operations like adjusting climate controls, media control, entering navigation address, eating, drinking, etc. or turning back or side to talk to other passenger in the vehicle or any other physical movement by the driver. The major reason behind the most of distracted driving accident is due to physical or manual distractions. According to a report by NHTSA The percentage of driver's text-messaging or visibly operating hand-held devices increased from 1.3 percent in 2011 to 1.5 percent in 2012, the hand held cell phone usage continued to be higher among females, maximum among 16 to 24 year-olds and lowermost among drivers 70 and older.

- **Cognitive** – Tasks that are defined as the mental workload associated with a task that involves thinking about something other than the driving task.Cognitive distraction includes any thoughts that absorb the driver's attention to the point where they are unable to focus on driving, "mind-off-road"



One another type of Driver Distraction is **Auditory** that is caused due to hearing something not related to driving.

4.2.3 Activities that can cause Distraction

The activities that can cause Distraction amongst drivers are given below:

- Using a cell phone
- Eating, drinking, or grooming
- Talking to passengers
- Reading, including map reading
- Using a PDA or navigation system
- Watching a video
- Changing the radio station, CD, or Mp3 player
- Texting
- Taking care of toddlers while driving

4.2.4 What is the Problem?

Driver Distraction is a major problem for the drivers but drivers are not the only one responsible for it.There are entities such as the government and laws by government which are not stringent enough to curb the distraction.

- Nearly all legislation focuses on banning only handheld phones or only texting while driving.
- All state laws and many employer policies allow hands-free cell phone use.
- Public opinion polls show people recognize the risks of talking on handheld phones and texting more than they recognize the risks of hands free phones.
- Many drivers mistakenly believe talking on a hands-free cell phone is safer than handheld devices.

4.2.5 Key Facts and Statistics

- In 2013, 3,154 people were killed in motor vehicle crashes involving distracted drivers. This represents a 6.7 percent decrease in the number of fatalities recorded in 2012. Unfortunately, approximately 424,000 people were injured, which is an increase from the 421,000 people who were injured in 2012.
- 10% of drivers of all ages under the age of 20 involved in fatal crashes were reported as distracted at the time of the crash. This age group has the largest proportion of drivers who were distracted.
- Drivers in there 20s make up 27 percent of the distracted drivers in fatal crashes .
- At any given daylight moment across America, approximately 660,000 drivers are using cell phones or manipulating electronic devices while driving, a number that has held steady since 2010
- Engaging in visual-manual subtasks (such as reaching for a phone, dialing and texting) associated

with the use of hand-held phones and other portable devices increased the risk of getting into a crash by three times

- Headset cell phone use is not substantially safer than hand-held use .
- A quarter of teens respond to a text message once or more every time they drive. 20 percent of teens and 10 percent of parents admit that they have extended, multi-message text conversations while driving.

4.2.6 Effort by Government to Curb Driver Distraction

According to the report “2013 Distracted Driving: Survey of the States “released by The Governors Highway Safety Association (GHSA) it's evident that more states are enacting and enforcing laws related to driver distraction.

Some of the key findings of this report were:

- All the states continue to pass distracted driving laws.
- States are making efforts to enforce the laws.
- States are using social media and are leveraging the technology in order to educate the drivers.
- States are giving focus to the teen drivers who are at the highest crash risk.
- States have recognized the power of partnering with other public and private firms to reinforce safety guidelines.
- States have improved their data collection practices so that they can better determine the magnitude of the problem.

4.3. Speech Recognition

4.3.1 Speech Recognition Concept

Speech is a complex phenomenon. The naive perception is often that speech is built with words, and each word consists of phonemes. The reality is unfortunately very different. Speech is a dynamic process without clearly distinguished parts. All modern descriptions of speech are to some degree probabilistic. Speech to text translation and other applications of speech are never 100% correct. That idea is rather unusual for software developers, who usually work with deterministic systems. And it creates a lot of issues specific only to speech technology. The common way to recognize speech is the following: we take waveform, split it on utterances by silences then try to recognize what's being said in each utterance.

Speech Recognition is one of the most researched concept of the present day. In its simple terms, Speech recognition is a process of converting spoken words into text. It is also known as Automatic Speech Recognition. This technology gained acceptance and shape in the early 1970s due to the research funded by Advance Research Project Agency in U.S Department of Defense . It has been widely in use since 1970s in various domains such as automotive industry, health care, military, IT support centers, telephone directory assistance, embedded applications, automatic voice translation into foreign languages etc.

4.3.2 Components of Speech Recognition system

The Speech Recognition system consists of the below basic components:

- a microphone, for the person to speak into.
- speech recognition software.
- a computer to take and interpret the speech.
- a good quality sound card for input and/or output.

At the heart of the software, we have the translation part which:

- Breaks down the spoken words into phonemes
- “Phonemes” are analyzed to see which units fits best, which can be derived from its dictionary
- System has to be trained to recognize factors associated with the user's voice e.g.. Speed, pitch

4.3.3 Classification of Speech Recognition System:

4.3.3.1 **Types of Speech Utterance**

- Isolated Words :It involves a reader's ability to recognize words individually from a list without taking help from the similar words to understand the context.It has the limited vocabulary.
- Connected Words :Speech is uttered continuously in this case hence the recognition becomes harder.It consists of large sentences and hence deal with big vocabulary.
- Continuous Speech : It is made up of connected words and focuses on understanding the sentences and has a large vocabulary.
- Spontaneous Speech : Spontaneous conversation is optimized for human-human communication and presents challenges for spoken language applications because they violate assumptions often applied in automatic processing technology.

4.3.3.2 **Types of Speaker Model**

- Speaker dependent models :This model is tailored to understand a particular person’s speech.In this case the reference template needs to changeed everytime the speaker changes.
- Speaker Independent models : This model is independent of its user’s speech.It recognises speech irrelevant of the speaker. The speaker- independent systems are more commercially attractive than dependent ones but are hard to implement.

4.3.3.3 **Types of Vocabulary**

- Small vocabulary –tens of words : The system uses very limited vocabulary.
- Medium vocabulary : The system uses large vocabulary which consists of nearly hundred of words.

- Large vocabulary :The system uses large vocabulary which consists of nearly thousands of words.
- Very-large vocabulary : The system uses large vocabulary which consists of tens of thousands of words.
- Out –of –Vocabulary –Mapping a word from the vocabulary into the unknown world .This more like natural word processing which is pretty hard to implement as it uses artificial intelligence algorithm.

4.3.4 Factors affecting accuracy of speech recognition systems

- Vocabulary size : The use of limited vocabulary in the system enhances the performance of the speech recognition system.
- Speaker dependence vs. independence : Speaker dependent systems are trained using audio from a particular person's speech while speaker independent system does not depend on a specific speaker's accent.Speaker dependent provides more performance than speaker independent system.Speech recognition system "adapt" to the user's voice, vocabulary, and speaking style to improve accuracy.
- Isolated, Discontinuous or continuous speech : Isolated speech consists of isolated words which comes with a pause and thus is not recommended for large vocabulary.This is similar to discontinuous speech whereas continuous speech comes with large sentences connected together with an intended meaning requires large vocabulary for a speech recognition system.
- Language constraints : The vocabulary can be defined and set as limited for the voice recognition system, however different words when connected in a specific way brings in different meaning to the table which is yet another limitation for the speech recognition system e.g.: "Red is apple the." is a sentence with not much meaning and which might be understood by the recognizer but will be of not much use.

- Read vs. Spontaneous Speech :In Automatic Speech Recognition, although speech derived from read texts, news broadcasts, and other similar contexts can be recognized with high accuracy, recognition performance decreases drastically for spontaneous speech.Spontaneous speech is basically what we humans speak in day to day life.Also,both spontaneous speech and read speech differ acoustically as well as linguistically. Compared with controlled read speech, spontaneous speech can be characterized by varied speaking rate, filled with pauses, corrections, hesitations, repetitions, partial words, and sometimes “sloppy” pronunciation
- Adverse conditions : The NHTSA considers distracted driving to include the following distractions as well like : other occupants in the car, eating, drinking, smoking, adjusting music/radio, adjusting environmental control, reaching for objects in car, and cell phone use.

4.3.5 **Acoustic Modelling**

An acoustic model is a basically a file that contains statistical representations of each of the distinct sounds that makes up a word. Each of these statistical representations is assigned a label called a phoneme.Thus, acoustic modelling can be compiled from the below :

- Establishing statistical representations for the feature vector sequences computed from the speech waveform.
- Pronunciation modeling. How fundamental speech units represent larger words?
- Feedback information - reshapes the speech vectors and gives noise robustness.
- Taking audio recordings of speech and their transcriptions and then compiling them into statistical representations of the sounds for words.

The ASR system block diagram basically works in two steps; in first step pre-processing is done with feature extraction, while second step covers acoustic modeling, language model, pattern recognition or transcription.

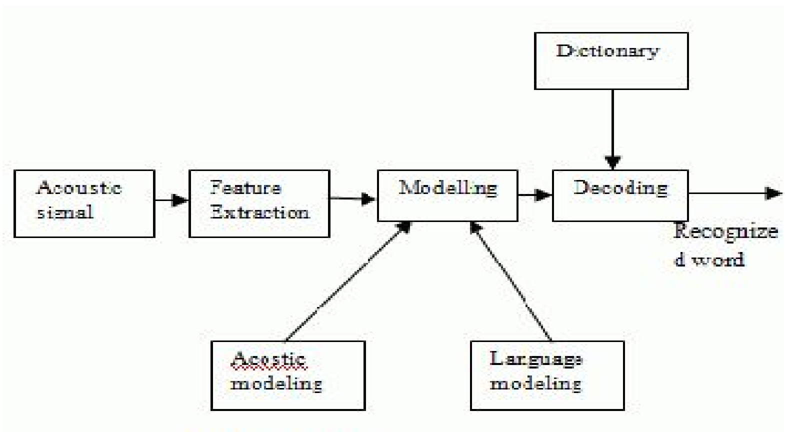


Fig. 1: ASR block diagram.

4.3.6 Language Modelling

A Statistical Language Model is a file used by a Speech Recognition Engine to recognize speech. It contains a large list of words and their probability of occurrence. It is used in dictation applications.Thus, language modelling is about :

- Probabilities of sequences of words.
- Provides context to distinguish between words and phrases that sound similar.eg: “recognize speech” and “Wreak a nice beach”
- Offers grammatical support for the words processed E.g.: “The milk is the cat”

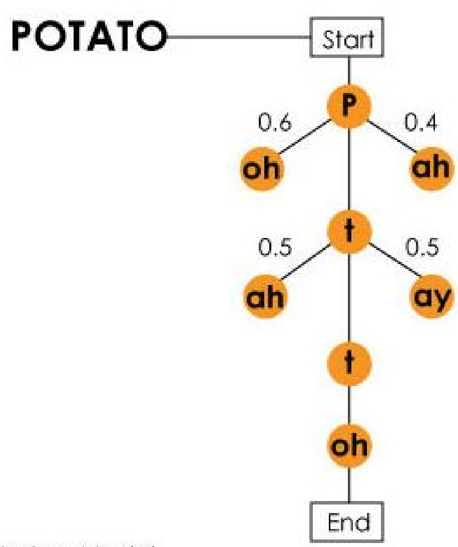
4.3.7 Types of Language Models:

- N-gram model -is a contiguous sequence of *n* items from a given sequence of text or speech.n-gram models are widely used in statistical natural language processing.
- Unigram model –an n-gram of size 1 is referred to as “unigram”.

Hidden Markov Models, n-gram models and neural networks are widely used in speech recognition systems. Since 2010, deep neural networks is used for learning algorithms to train the system

4.3.7.1 Hidden Markov Model

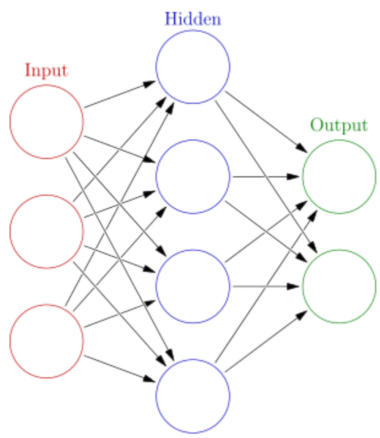
The tool is used to model the time series data.A hidden Markov model can be considered a generalization of a mixture model where the hidden variables (or latent variables), which control the mixture component to be selected for each observation, are related through a Markov process rather than independent of each other.In the below example if we say the word “potato” than the probability of word “oh” is 0.6 and “ah” is 0.4 and similarly the hidden probabilities would be calculated till the last phoneme “oh”.



Markov Model

4.3.7.2 Neural Network

Most current speech recognition systems use hidden Markov models (HMMs) to deal with the temporal variability of speech and Gaussian mixture models (GMMs) to determine how well each state of each HMM fits a frame or a short window of frames of coefficients that represents the acoustic input. An alternative way to evaluate the fit is to use a feed-forward neural network that takes several frames of coefficients as input and produces posterior probabilities over HMM states as output. The below diagram signifies hidden states which model uses before an output.



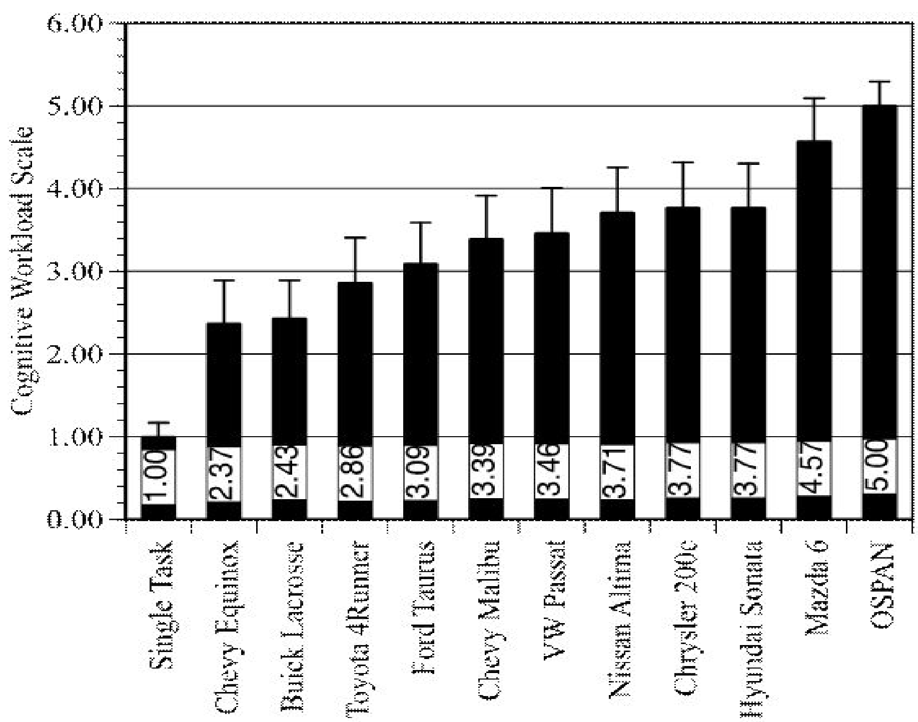
4.3.8 In-car Speech recognition system (Automotive Industry)

In the USA, current voice interfaces include Ford SYNC, Chrysler UConnect, GM MyLink, Hyundai Genesis, and Toyota navigation with Entune. The commonly supported applications are navigation (e.g., destination entry, route guidance, and traffic information) and music selection (selecting, playing, and pausing songs on MP3players, AM/ FM/XM radios), as well as those related to cellular phones (answering and placing calls, searching contact lists, and various tasks associated with text messages).

4.3.8.1 Contemporary Speech Recognition systems

- Dragon NaturallySpeaking
- Android SDK
- Apple Car plays
- Google APIs
- CMU Sphinx
- Toyota's Entune system
- Chevrolet's My Link system
- Chrysler's Uconnect system
- Hyundai's Blue link system
- Mercedes's Command system

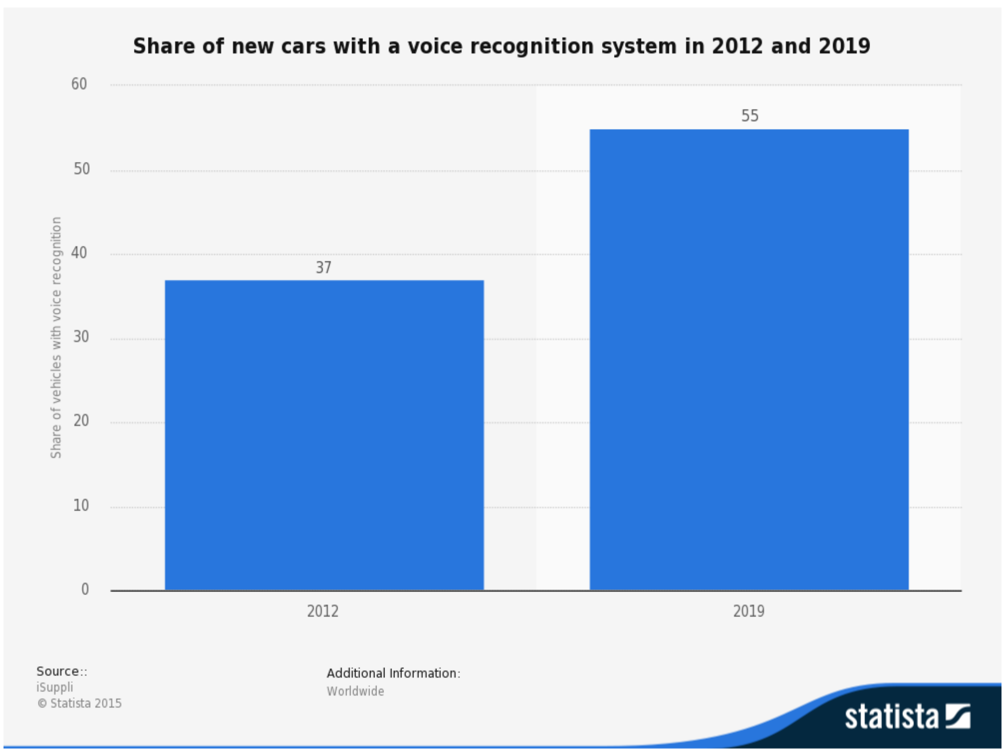
4.3.8.2 Comparison study between current speech recognition system[1]



4.3.9 Speech Recognition –solution and a cause of driver distraction

- Most of the people claimed : “speech recognition technology is safer” as no eyes off the road or hands off the steering wheel”
- Speech recognition is assumed to be a panacea for driver distraction offering an alternative to the visual/manual demand of the system thus;
- Use of handsets while driving is illegal in 14 states
- Use of “hands-free” voice controls is being encouraged

As per the research by Statista[2], the survey shows the twenty percent growth in cars with speech recognition system installed in 2012 and 2019.The share of voice recognition system equipped cars is predicted to be increased from 37 percent in 2012 to 55 percent in 2019.



Studies and latest research in the area has proven voice recognition system to be curse more than the blessing.Please find the latest research details in the next section.

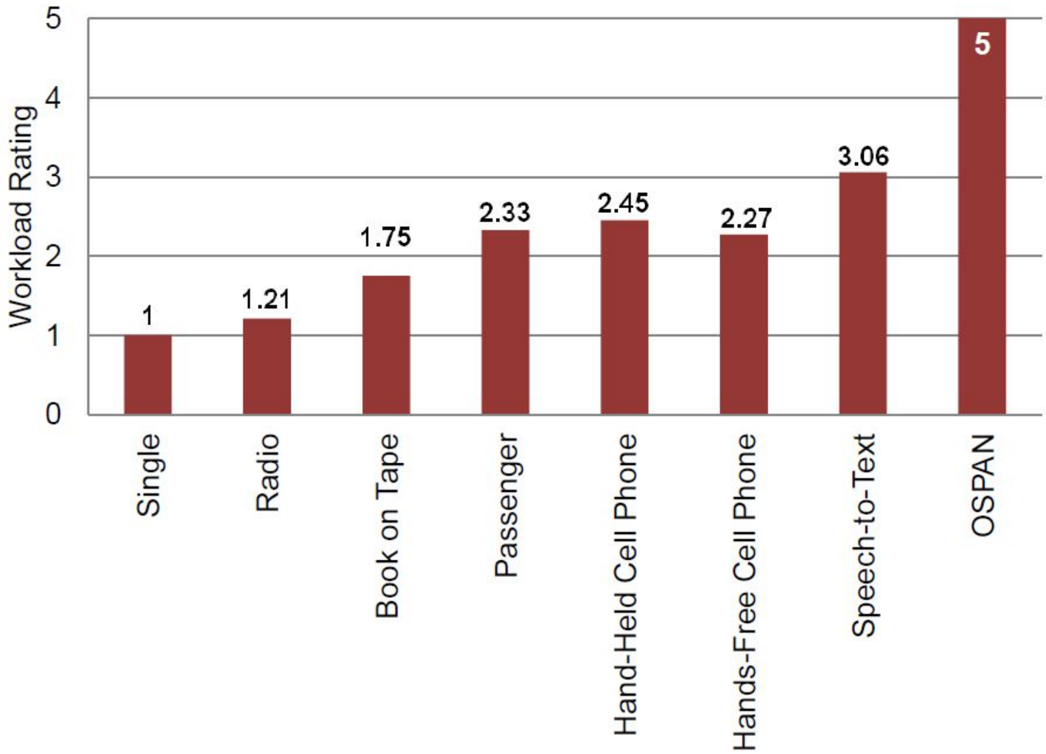
4.3.10 Recent research on Speech Recognition technology

- **Slow Reaction time while using speech to text**

The research conducted by AAA foundation in June 2013[3], showed that the mental workload was high while using the infotainment system with speech as the secondary task to driving.This led to slow reaction times and increased cognitive distraction.Driver distraction from secondary in-vehicle activities is increasingly recognized as a significant source of injuries and fatalities on the roadway.The results of the research conducted by AAA were to measure and understand cognitive distraction in the vehicle. The users were asked to drive in the below conditions :

  - Normal Driving with no forced distraction
  - Primary task as driving while listening to a radio
  - Primary task as driving while listening to a CD tape
  - Primary task as driving while talking to a passenger
  - Primary task as driving while talking with hand held phone and using the hands free
  - Primary task as driving while secondary task of talking to the infotainment system

The workload rating on the driver was recorded in all the above situations and as per the plotted graph and related study the maximum workload was found when the driver had to interact with the speech recognition system.



- **Voice controls are as distracting as making a phone call**

The research conducted by American Automobile Association Foundation 2014[4] proves the fact that Voice-activated systems designed to keep drivers' eyes on the road are as distracting as making a mobile phone call while driving.The researchers tested six built-in speech recognition systems in latest cars, including the Ford MyFord Touch voice-control system, as well as Apple's Siri voice assistant on an iPhone, on a sample of 45 drivers, who were tested for driver's mental capacity and reaction times. The result indicated that common voice tasks were generally more demanding than natural conversations, listening to the radio, or listening to a book on tape. Also, Siri, Apple's natural-language voice-control system and assistant, was found to be even more distracting than the fixed-command control systems in the recent cars.

- **Cognitive Distraction due to In-Vehicle Information Systems**

  In 2011, studies by AAA confirmed the amount of mental distraction is huge with the in-car infotainment system.The below figure depicts the results of the study where the mid danger were experienced by the drivers who were listening to music as the secondary task while driving.The moderate danger was reported in cases when the drivers checked the cell phones while driving , however the maximum workload and high danger was reported when the driver had to interact with the voice activated recognition system.

- **In-car environment makes the speech recognition system inefficient**

  The environment for in-vehicle system interaction is highly dynamic and interactive, and criteria regarding usability, learning ability, efficiency, memorization, error handling and satisfaction, have been extended also to comprise the requirement that driver distraction must be avoided.Hence, the primary task is subjected to a high visual load with variable cognitive load, leaving only whatever resources remain for secondary task interaction.

- **Difference in reaction time with email usage**

  Also, as the study conducted by students of Cognitive Systems Laboratory, University of Iowa[5] , the effect of speech based emails on the driver was analysed.The study uses a car-following task to evaluate how a speech-based e-mail system affects drivers' response to a periodically braking lead vehicle. A baseline condition with no email system was compared to a simple and a complex e-mail system in both simple and complex driving environments. The results show a 30% (310 msec) increase in reaction time when the speech-based system is present. Subjective workload ratings also indicate that speech-based interaction introduces a significant cognitive load, which is highest for the complex e-mail system.

4.3.11 Future in Speech Recognition System

- **QNX Helps Automakers Gear Up for Integrated Driving Experiences at 2015 CES**

  As per the latest research QNX Software systems have successfully demonstrated the integration of infotainment and ADAS(Automotive Driver Assistance systems) technologies to enable simple and safe drive.[6]

- **Advanced Auto Safety Report 2014**

  As per the Telematics update survey[16] of the international market, automobile industry should understand and work on below :

  - **Driver distraction:**Understand what driver distraction is and what its many causes and effects are.
  - **Guidelines and regulations:**Learn about their latest regulatory efforts and understand how to keep up with their ever-evolving and, at times, conflicting demands
  - **Interfaces and interactions:** Learn about the latest advances in interface technologies
  - **Strategies for mitigating driver distraction through HMI design:**Understand how to combine various interfaces and interactions into overall strategies for managing driver distraction.
  - **Driver distraction and automated driving:**Understand the situations where a driver's attention will still be required, from ADAS warnings to retaking control of the vehicle

- **Voice recognition and gesture controls by ECN staff,2014**

  Recent ECN survey[17] stated that “Cars of the future will be connected to everything around them including consumer devices, traffic signals and pavement-embedded sensors, and even other cars on the road. It will take a lot to bring this so called ‘network on wheels’ to life, and a lot of progress will be made in the next five years, so long as automakers put an increased focus on building smart systems that enable reliable data connections and ultra-speedy user interfaces.”

4.3.12 CONCLUSION

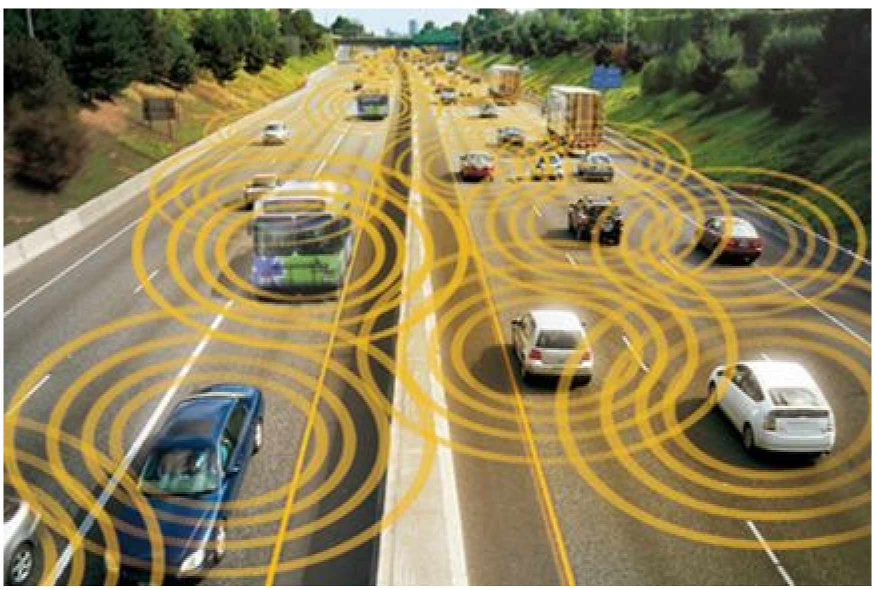
Thus as per the recent studies,the Internet Of Things puzzle will soon be solved and infotainment system with better speech recognition system would become a reality. ADAS in addition to the gesture controls would help the speech recognition technology to become more reliable. Hence, driving would become a more safer and enjoyable experience for the drivers on the roads.

4.4. Autonomous Cars

4.4.1 What are autonomous cars?

Wikipedia defines an autonomous car as an uncrewed vehicle, driverless car, self-driving car and robotic car, is an autonomous vehicle capable of fulfilling the main transportation capabilities of a traditional car. As an autonomous vehicle, it is capable of sensing its environment and navigating without human input.

Autonomous vehicles sense their surroundings with such techniques as radar, lidar, GPS, Odometry, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. By definition, autonomous vehicles are capable of updating their maps based on sensory input, allowing the vehicles to keep track of their position even when conditions change or when they enter uncharted environments.



Autonomous cars have control systems that are capable of analyzing sensory data to distinguish between different objects on the road, which is very useful in planning a path to the desired destination.

4.4.2 Why Do We Need Them?

So many aspects of our lives have gone to automation that everything else, including driving a vehicle, is on the table for technology to take over. Google has their own project working towards that end. But still, the first thought that most people have when they hear about cars that drive themselves is that it’s probably a bad idea.

If that’s the case, what are the benefits of these cars? Will they be safe? And to what extent will they actually make the roads safer?

There are four good reasons that make perfecting driverless car technology something that we should push for:

Traffic: One of the long-term goals of the autonomous driving movement is to connect vehicles with each other as well as the roads themselves in a way that are not possible with human drivers. Vehicle spacing in high-traffic areas causes congestion that could easily be alleviated through "smart" cars that engaged with each other. If cars had the ability to be put on autopilot and connected with one another, they could all start pulling forward in unison which would be both safer and more efficient.

Productivity: It's a sad statement about the direction that society is heading, but it's a reality nonetheless. Being able to use drive times to do work, spend time with family, or simply relax is a clear potential benefit of having an autonomous car. With an average commute of 35 minutes in metro areas, this time could be spent doing anything other than paying attention to the road. There are instances when this is happening already even with a human driver.

Handicap Transportation: Today, a blind person or someone with other disabilities must rely on others for their transportation. The prospects of empowerment for the handicapped is a huge potential benefit of autonomous vehicles. Driverless vehicle technology isn't simply for convenience or safety. It's possible for those who are completely unable to drive themselves to realize the freedom of "one's own wheels" through autonomous vehicles.

Fewer Accidents: This is the component that is both most compelling as well as drawing the most skepticism. Some believe that computers lack the ability to take in every factor in the surrounding environment as well as within the vehicle itself, analyze the data, and make the right decisions about how to respond to circumstances.

Others think the trade-off of fewer drunk, unskilled, or distracted drivers outweighs the potential drawbacks of non-human road interactions. This was highlighted in August, 2011, when Google experienced their first driverless car crash. The company is quick to note that it was under human control at the time.

4.4.3 Automotives as a microcosm of IoT

According to the automobile industry analysts IHS automotive, fully autonomous cars will reach the market in 2025, and will take 10 years to reach sales levels of 11.8 million – 9 percent of the global auto trade. Carmakers, including Nissan and Daimler, are more optimistic, expecting to have self-driving cars on the road as early as 2020.

We won't all be swept to work in self-driving cars tomorrow. According to the automobile industry analysts IHS automotive, fully autonomous cars will reach the market in 2025, and will take 10 years to reach sales levels of 11.8 million – 9 percent of the global auto trade. Carmakers, including Nissan and Daimler, are more optimistic, expecting to have self-driving cars on the road as early as 2020.

However, the technologies that make self-driving cars possible are already impacting the way we drive, and there will be many more changes before the first completely hands-free car enters general circulation. The latest Mercedes S-Class has the option of a service called "Stop & Go

Pilot". Using twelve ultrasonic sensors, five cameras and six radar sensors, the car is able to "see" the cars around it and drive automatically in slow-moving traffic – keeping a safe distance from the car in front, and making minor steering adjustments to stay in lane. In traffic jams the S-class can creep forward of its own accord. Once the traffic speed goes above six miles per hour, it sounds an alarm if the driver's hands are off the wheel, to bring attention back to the job of driving. BMW's 5 Series has automated another tedious part of driving – parallel parking – with its park Assist function. When the car passes a suitable space, the system will plot and implement a parking route, with the driver simply having to control acceleration and braking.

Traditionally, the vehicle has been the extension of the man's ambulatory system, docile to the driver's commands. Recent advances in communications, controls and embedded systems have changed this model, paving the way to the Intelligent Vehicle Grid. The car is now a formidable sensor platform, absorbing information from the environment (and from other cars) and feeding it to drivers and infrastructure to assist in safe navigation, pollution control and traffic management. The next step in this evolution is just around the corner: the Internet of Autonomous Vehicles.

Pioneered by the Google car, the Internet of Vehicles will be a distributed transport fabric capable to make its own decisions about driving customers to their destinations. Like other important instantiations of the Internet of Things (e.g., the smart building), the Internet of Vehicles will have communications, storage, intelligence, and learning capabilities to anticipate the customer's' intentions. The concept that will help transition to the Internet of Vehicles is the Vehicular Cloud, the equivalent of Internet cloud for vehicles, providing all the services required by the autonomous vehicles.

Network Effects

The benefits of connectivity extend beyond convenience. By transmitting diagnostic information, potentially dangerous faults can be identified remotely and repaired before they are even noticeable to the driver. With easy updates on a car's location and speed, insurers can check whether a driver is a good risk, parents can make sure their children are actually borrowing the car to drive carefully to the shops, and theft can be immediately detected. In some ways, the car of the future – battery-powered and constantly connected – will be more like a computer with wheels, compared with the controlled explosions of the internal combustion engine.

Of course, the more important connectivity becomes, the more vital it is that it can be maintained. Losing access to map and navigation data is frustrating in a strange city – and far more so on the motorway.

The connected car can create a wireless hot spot, giving internet access to passengers. This can be more than just a diversion on long journeys, though, or a way to dial into the office network from a service station car park. Emergency service vehicles can access information on their way to an emergency, and access medical records and remote consultations while transporting injured people to hospital.

In preparation for the 2014 World Cup, Brazil's Ministry of Justice has deployed 27 mobile command and control centres – trucks containing a mobile base of operations. Connected to the internet and each other, the centres can set up a monitoring network of IP cameras, monitor situations, issue citations and process fines on the spot – while also creating mobile wireless hotspots for other government agents.

4.4.4 Conclusion

The future seems to be one where driving is increasingly optional rather than compulsory, in more and more situations. Despite suspicions about driverless cars, statistics suggest that most accidents are caused by inattention, alcohol or exhaustion – conditions automated cars do not experience. So, even the driver may become a passenger for many journeys in the future, using their in-car internet connection for entertainment, productivity or a well-earned rest.

Connectivity and "smartness" have been entering the automotive world through many different windows – apps on smartphones, navigation systems, automatic parking and even driving-on-demand services like Uber or Zipcar, where technology and connectivity are used to give temporary access to a car, with or without a driver. The integration of these abilities – and more – into the connected car, and the connected car into the Internet of Everything, has the potential to transform transportation, just as the internet has disrupted and reshaped so many other industries.

4.5. Cyber Cars

Cyber Car is a car that is equipped with Internet access, and usually also with a wireless local area network.

This allows the car to share internet access with other devices both inside as well as outside the vehicle. Often, the car is also outfitted with special technologies that tap into the internet or wireless LAN and provide additional benefits to the driver. Examples include: automatic notification of crashes, notification of speeding and safety alerts.

These cars usually have a head-unit, in car entertainment unit, in-dash system with a screen from which the operations of the connections can be seen or managed by the driver. Types of functions that can be made include music/audio playing, smartphone apps, navigation, roadside assistance, voice commands, contextual help/offers, parking apps, engine controls and car diagnosis.

A cyber car may provide many of the following features:

- Real-time monitoring of the vehicle’s status and operation.
- Savings, through being able to detect potential problems with the car early on.
- Tracking of the vehicle in the event of car-jacking and alerts to safeguard the driver and relatives.
- Remote control of the vehicle in countries where this is allowed by law.
- Optimization of routes and driving expenses.
- Monitoring and remote diagnosis of the vehicle.
- Software updating with the possibility of changing the car’s configuration remotely.
- Mobile phones or tablets can be used to control HVAC systems as well as other operational systems, suspension, etc. on the vehicle.
- Safety systems and automatic emergency calls in the event of an accident.Maps, real-time traffic information and satellite imaging.
- Real-time information about fuel prices and the location of the nearest service stations.
- Access the Internet, instant messaging, e-mail, social media.
- Streaming radio and other music services.

- Videos and other entertainment apps for passengers.
- Information and geo-location of nearby points of interest.
- Information on the weather, breaking news

Pros of cyber cars:

- Emergency services: GM's On-star platform connects the car automatically to an emergency service in case the passenger or driver does not respond in case of an emergency.
- Vehicles of the future are expected to sense and "see" things, communicate through the cloud, talk to other vehicles, and pick up information from those vehicles. You will know there are power lines down over the road, or that there are children playing on the road up ahead, because vehicles will sense that information and will pass it on to other vehicles, thus making it safer all around.
- Vehicles will also know the condition of the vehicles around them; they will know if there is a problem emerging and will transmit this information to other vehicles. For example, a large semi-truck that is driving alongside you is about to break down. Since your vehicle is in contact with the truck, you will feel safer knowing what's going on.
- This technology can be used in school buses and delivery vehicles. This can help parents know the exact location of their child's school bus, how fast it's traveling and when it will reach home.
- It can provide lane departure warnings to drivers.

Cons of cyber cars:

- With so many features and constant back and forth with the car, driver distraction increases.
- Due to increased connectivity, opportunities for hackers, criminals or governments to spy on drivers increases.

- The risks of systems being hacked in ways that may cause auto malfunctions and/or accidents.
- Due to constant connectivity, increased data collection may cause privacy concerns. For example, The California Air Resources Board (CARB) is proposing that auto manufacturers share driving data with them so they can develop better regulations.The California Air Resources Board (CARB) is proposing that auto manufacturers share driving data with them so they can develop better regulations.

Cyber Security: The risk of hacking

There have been many instances of cars being hacked. This poses the biggest security risk for cyber cars. This video http://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/ shows two security engineers remotely hack into a Jeep and stop it.

Here is a list of most hack-able cars from last year:

CAR	ATTACK SURFACE	NETWORK ARCHITECTURE	CYBER PHYSICAL
2014 Jeep Cherokee	++	++	++
2015 Cadillac Escalade	++	+	+
2014 Ford Fusion	++	-	++
2014 Dodge Ram 3500	++	++	--
2014 BMW X3	++	--	++
2014 Chrysler 300	++	-	++
2014 Range Rover Evoque	++	-	++
2014 Toyota Prius	+	+	++
2010 Toyota Prius	+	+	++
2014 Infiniti Q50	++	+	+
2014 Audi A8	++	--	+
2010 Infiniti G37	-	++	+
2014 BMW 3 Series	++	--	+
2014 BMW i12	++	--	+
2014 Dodge Viper	++	-	--
2014 Honda Accord LX	-	+	+
2010 Range Rover Sport	-	--	-
2006 Range Rover Sport	-	--	-
2006 Toyota Prius	-	--	--
2006 Ford Fusion	--	--	--

A '+' sign means a car is 'more hackable', and a '-'sign represents a 'less hackable' vehicle.

A car's wireless **'attack surface'** includes the range of features that could be hacked, including Bluetooth, Wi-Fi, mobile network connections, key fobs, and tyre pressure monitoring systems.

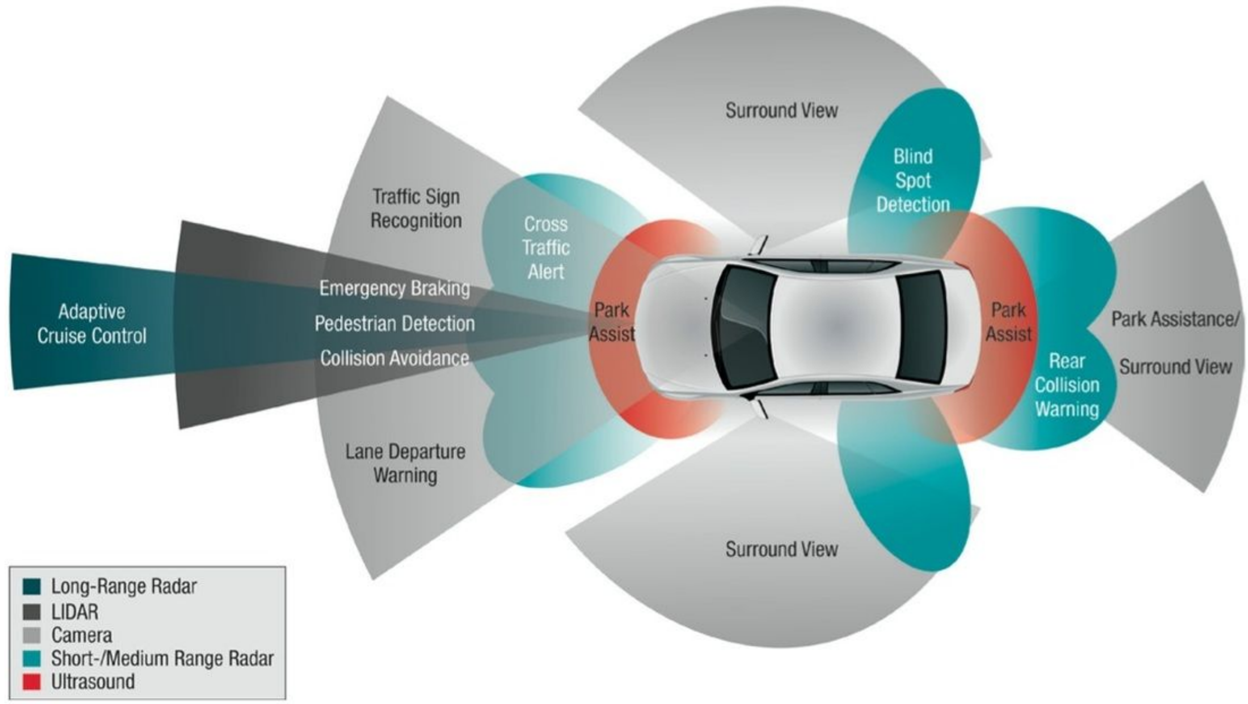
The **network architecture** includes how much access these features give to the vehicle's critical systems, such as the horn, the steering and brakes.

Cyber physical relates to capabilities such as automated braking and parking sensors that could be controlled using wireless commands.

Conclusion

As we have seen, cyber car has many pros as well as cons. Deeper research into security cyber security of cars will make sure that cons are minimized and the pros outweigh cons once the technology reaches a mature state.

4.6 ADVANCED DRIVER ASSISTANCE SYSTEMS (ADAS)



Advanced driver assistance systems (ADAS) are systems developed to automate/adapt/enhance vehicle systems for safety and better driving. Safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems, or to avoid collisions by implementing safeguards and taking over control of the vehicle. Adaptive features may automate lighting, provide adaptive cruise control, automate braking, incorporate GPS/ traffic warnings, connect to smartphones, alert driver to other cars or dangers, keep the driver in the correct lane, or show what is in blind spots.

There are many forms of ADAS available; some features are built into cars or are available as an add-on package. Also, there are aftermarket solutions available for some late model cars.

Advanced driver assistance systems are one of the fastest-growing segments in automotive electronics.

ADAS technology can be based upon vision/camera systems, sensor technology, car data networks, Vehicle-to-vehicle (V2V), or Vehicle-to-Infrastructure systems.

Next-generation ADAS will increasingly leverage wireless network connectivity to offer improved value by using car-to-car and car-to-infrastructure data.

Classification of ADAS:

- Lane Change Assistance Systems
    - Lane Departure Warning System (LDWS)
    - Blind Spot Detection (BSD)
- Forward or Rearward looking Systems
    - Collision Warning Systems: Pedestrian Detection System (PSD)
    - Rear Cross Traffic Alert (RCTA)
- Cruise Control Systems
    - Adaptive Cruise Control (ACC)
    - ACC with Stop & Go
- Adaptive Light Control Systems
- Park Assistance System (PAS)
- Night Vision System (NVS)
- Traffic Sign and Traffic Light Recognition Systems
    - Traffic Sign Recognition System (TSRS)
    - Traffic Light Recognition System (TLRS)
- Navigation and Map Supported Systems
- Vehicle Interior Observation and Driver Monitoring Systems
- Autonomous Driving
    - Low Speed Companion
    - Parking Companion
    - Parking Pilot
    - Highway Chauffeur
    - Highway Pilot

Appendix

A. Raw Data of Response Times

Volunteer	Placement	451	396	278	Popup	Total
Subject 1	Top	1562	1602	1629	1893	6686
	Bottom	1985	1806	1922	1840	7553
Subject 2	Top	4414	5795	3337	17960	31506
	Bottom	4784	3021	4819	6216	18840
Subject 3	Top	2316	2096	1933	2853	9198
	Bottom	1977	2006	2523	17399	23905
Subject 4	Top	1227	1446	5662	4752	13087
	Bottom	6120	3059	2100	3191	14470
Subject 5	Top	3850	2474	3970	3057	13351
	Bottom	5882	5461	2575	2983	16901
Subject 6	Top	2746	4345	3941	14616	25648
	Bottom	5709	5602	5716	7319	24346
Subject 7	Top	3647	2014	1610	7197	14468
	Bottom	3011	2556	2599	6247	14413
Subject 8	Top	4387	4340	3448	13826	26001
	Bottom	5326	4761	5061	4132	19280
Subject 9	Top	4142	1733	2636	14173	22684
	Bottom	5668	3613	2780	15381	27442

Subject 10	Top	5052	2545	4307	15426	27330
	Bottom	5311	5040	4038	9223	23612
Subject 11	Top	4110	5135	5414	15914	30573
	Bottom	5608	2079	4342	13436	25465
Subject 12	Top	1898	1422	1602	8241	13163
	Bottom	2163	1305	1662	6564	11694
Subject 13	Top	2367	5039	4753	10931	23090
	Bottom	4161	3849	5950	16069	30029
Subject 14	Top	4323	2610	2751	4752	14436
	Bottom	5231	5052	4216	7385	21884
Subject 15	Top	1753	5070	3485	3609	13917
	Bottom	5630	4256	3333	16865	30084
Subject 16	Top	5164	5057	1778	3458	15457
	Bottom	5965	1883	3838	6210	17896
Subject 17	Top	2188	4314	1791	13979	22272
	Bottom	4680	2783	4635	2547	14645
Subject 18	Top	5684	5162	4501	6360	21707
	Bottom	5954	1828	5051	12343	25176
Subject 19	Top	2616	1957	1606	5318	11497
	Bottom	2174	1632	3021	2536	9363

Subject 20	Top	4360	5932	2358	6989	19639
	Bottom	4930	5635	5808	6651	23024
Subject 21	Top	2682	5454	2419	11866	22421
	Bottom	3698	4951	3882	15511	28042
Subject 22	Top	4409	2234	2674	8234	17551
	Bottom	5164	2460	4713	3221	15558
Subject 23	Top	3504	2208	2076	2742	10530
	Bottom	4527	4465	5802	15528	30322
Subject 24	Top	2569	2913	3392	15212	24086
	Bottom	3052	5083	4650	10613	23398
Subject 25	Top	3902	4618	2102	4161	14783
	Bottom	5508	2411	5840	17312	31071
Subject 26	Top	2669	5214	4158	3872	15913
	Bottom	3786	3721	5057	15412	27976
Subject 27	Top	4553	2513	5196	5547	17809
	Bottom	4767	5120	5928	10095	25910
Subject 28	Top	5532	3282	5836	8619	23269
	Bottom	5686	5354	3943	12187	27170
Subject 29	Top	2721	2998	3166	7307	16192
	Bottom	2852	4359	4343	14856	26410

Subject 30	Top	2836	2021	2536	2645	10038
	Bottom	1786	2531	2094	8256	14667
Subject 31	Top	5648	3497	3719	4153	17017
	Bottom	5788	1629	3429	5374	16220
Subject 32	Top	3693	6000	1546	2608	13847
	Bottom	5165	5166	2838	8823	21992
Subject 33	Top	5047	4723	4390	9663	23823
	Bottom	5608	4660	5708	9533	25509
Subject 34	Top	7130	1971	4693	16329	30123
	Bottom	2661	2827	3589	9245	18322
Subject 35	Top	4585	5958	4223	11384	26150
	Bottom	5222	5028	3413	7433	21096
Subject 36	Top	1986	3888	2243	9304	17421
	Bottom	4801	5992	2079	12912	25784
Subject 37	Top	5632	5458	5092	7312	23494
	Bottom	5773	3557	2716	3097	15143
Subject 38	Top	5789	2950	3374	3620	15733
	Bottom	5846	3140	2958	11109	23053
Subject 39	Top	3853	2464	4502	12312	23131
	Bottom	4574	2216	4497	5905	17192

Subject 40	Top	2023	3397	1512	9894	16826
	Bottom	3070	3389	5421	8353	20233
Subject 41	Top	2061	3311	5159	4544	15075
	Bottom	3310	2504	1973	13867	21654
Subject 42	Top	2124	1900	3669	3849	11542
	Bottom	5603	5028	3192	4725	18548
Subject 43	Top	4801	3905	4564	5455	18725
	Bottom	5193	5308	3504	17752	31757
Subject 44	Top	4681	3410	3649	17530	29270
	Bottom	5372	3419	4498	14849	28138
Subject 45	Top	1448	2086	1826	3054	8414
	Bottom	4576	2499	2510	10683	20268
Subject 46	Top	3857	5289	1905	8732	19783
	Bottom	4258	4501	5813	11483	26055

Table 2. Raw Data of Response Times

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