IN-VEHICLE INFOTAINMENT SYSTEMS

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Abstract: An emerging technology in the field of automobile manufacturing industry is In-Vehicle Infotainment (IVI). It is an integration of entertainment, multimedia and driver assisting technologies in a single module. This survey paper focuses on ideas such as the need for an IVI system in vehicles, the advantages it offers over other similar technologies like stereo systems, LCD televisions, Global Positioning System (GPS), etc. We describe in detail the modules that are integrated into an IVI system viz. rear seat entertainment, external connectivity, connectivity to mobile devices, advanced driver assistance systems and security systems. We then talk about modules that have not yet found implementation, but could be integrated into future IVI systems.

Keywords: Automotive Infotainment, Entertainment, Connectivity, Driver Assistance, Security.

I. INTRODUCTION

In- Vehicle Infotainment, also called as Automotive Infotainment is a technology that came into existence out of the need for better driver assistance systems in automobiles, particularly cars. Another driving factor was to provide good quality rear seat entertainment services. Thus In- Vehicle Infotainment (IVI) led to the transformation of an ordinary car; into a 'smart car'. A 'smart car' is the one that provides excellent entertainment facilities such as audio, video, etc as well as provide technologies that can assist the driver. For example: GPS, vehicle parking assisting systems, etc. Cars normally come with pre installed audio and visual systems that provide satisfactory rear seat entertainment. So a question arises as to why then do we need a separate In-vehicle infotainment system?
An IVI system besides rear seat entertainment provides a large number of driver assistance systems. And this is the kind of system we are looking at, one no doubt provides good entertainment, but in addition, a system that assists a driver while parking a car, alerts him on a congested traffic route and suggests an alternative path on his IVI system, notifies him whether or not everything is working fine inside a car. An IVI system provides for internet connectivity inside a car.
IVI contains a number of individual working modules that have been elaborated further in the report. Each of these modules is a combination of hardware and software. The modules contain embedded microcontrollers which take inputs from user and drive a display device. These microcontrollers may be programmed to work as per a desired functionality. Microcontrollers form the "brain" of these systems, where the entire processing work takes place. For example: Processing of audio files to play music from a source file, etc.
In the following part of our survey paper, we aim at explaining the IVI system framework, the numerous modules that are a part of them and how these modules of the system work independently. We also aim at explaining the technologies used in them, the protocols followed, etc.
We shall now elaborate the various modules in an IVI system. These modules are:
· Rear seat entertainment.
· Internet connectivity in cars.
· External connectivity.
· Advanced driver assistance functions.
· Security issues in cars and systems for the same.

II. MODULES

A. REAR SEAT ENTERTAINMENT

Rear seat entertainment can be divided into two sub modules viz. the audio system and the video system.

1. AUDIO:
In this part of the paper, we stress on following points regarding a stereo system in a car:
a) The basic components of an audio system and the functions of each component.

Speakers:
Speakers take an amplified electrical signal and convert it into mechanical energy that moves the speaker cone back and forth to create sound.

Subwoofers:
Subwoofers are specialized loudspeakers that are capable of reproducing only low ranged audio frequencies known as bass.

Amplifiers:
Amplifiers 'amplify' an audio output. In other words, they just increase the intensity of sound without affecting sound quality.

b) INTEGRATING AN AUDIO SYSTEM INTO INFOTAINMENT SYSTEM:

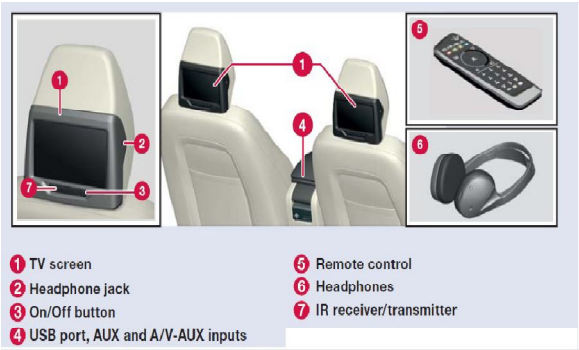
Interface is the unit that a user interacts with, in order to play music in his car. This interface is a physical unit that contains a CD/DVD drive, a USB port, etc. Thus a user can insert his audio CD into the CD drive or connect a USB stick that contains music files. Adjusting volume, changing tracks, current song information, display of various menus, etc are other functions implemented through this interface. But an infotainment system differs from a typical car audio system. In an infotainment system, there is a single point of access to a large number of modules inside a car, one of which is an audio system. Thus, it is the interface of an infotainment system through which a user will access his audio system unlike typical audio systems that provide an interface specific only to the audio system and which is of no use to other modules inside a car.

2. VIDEO:

The car should be equipped with an exclusive multimedia system. The Rear Seat Entertainment system augments the car's normal audio system with:

· Two TV screens
· A/V-AUX input that enables the connection of e.g. video or games console
· Wireless headphones
· Remote control

This system makes it possible to watch video, play back music, listen to radio, watch TV or connect other external devices (e.g. a games console).The system can be controlled from the front TV screen as well which is the parental control.



Rear seat entertainment services:-

A Rear seat entertainment system provides following facilities to the customers:

Digital TV:

In order to play all the normal TV channels we play at home TV must be properly mounted i.e. the TV antenna is used in the car just like the one used for playing FM radios.

DVD player:

If you press the button provided on the screen the screen comes out and there is a DVD holder for playing your DVD. You can thus watch your favourite movies and songs on the go.

Video Gaming:

In order to have headrest monitors that can display video games and other types of media, the monitors need to be able to accept more than one media input at a time.

Internet Access:

The passengers seating at the rear seats can easily use the in car wifi to access the internet services like social networking, web search etc.

Play content from your Smartphone:

In order to connect to your Smartphone the Bluetooth technology with is available in almost all cars now is used. Also NFC technology can be used to connect the monitors to the smart phones.

As mentioned above, an IVI system uses Near Field Communication (NFC) for establishing a connection between various Infotainment devices and a smart phone. So in the following unit, we describe the details of NFC.

3. NEAR FIELD COMMUNICATION:

Near field communication (NFC) is a technology that is used for establishing a wireless connection between two devices. This connection may then be used for data transfer, remote login, etc.

In this report, we propose the use of near field communication in order to connect your smart phone to an audio system that starts playing music files that are actually present on your smart phone. In this part, we present the details of NFC. NFC provides short range radio communication between two or more devices.

Now there are other technologies that provide this communication as well like Bluetooth, Infrared communication, etc. So where does NFC fare better than these technologies? Well, here are some of the advantages of NFC over Bluetooth:

· NFC has a lesser power consumption than Bluetooth.
· No pairing of two devices is needed.
· Setting up an NFC connection between devices is much faster as compared to Bluetooth.

Setting up a connection using NFC:

Devices using NFC technology are embedded with an NFC chip. It is this chip that sets up a connection with other such NFC embedded devices. With NFC, you just need to touch the two devices in order to set up a connection between them. This is exactly the kind of connection we are looking at in our infotainment system. The infotainment system would be embedded with an NFC chip. So all you need to do is touch your NFC smart phone to the infotainment system and they are already connected! Thus

infotainment system reduces a user's time that is needed to set up a Bluetooth connection. The alternative use of an NFC connection offers celerity.

B. CONNECTED CARS

"Connected Cars**"** are cars that access, consume, create, enrich, direct, and share digital information between businesses, people, organizations, infrastructures, and things.

There are two sub-modules in connected cars. In the first sub module we will discuss the ways of accessing internet in cars. In the second sub module we will discuss about the networking of cars.

1. WAYS OF ACCESSING INTERNET:

3G Routers:

There are vehicle based 3G-WiFi routers that allow any Wi-Fi equipped laptop, tablet or mobile phone to access the internet from within the vehicle while travelling. Connecting to the in-car Wi-Fi hotspot is just as easy as connecting to any other Wi-Fi network. The Rear-seat entertainment displays can also use the same Wifi connectivity. It has just one sim card and thus one mobile broadband connection. Total 8 devices can connect to it at a time and also to each other for file sharing and other tasks.

USB Mobile Broadband Dongle:

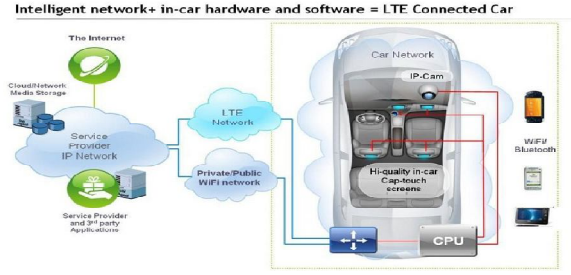
The user has to plug his mobile broadband dongle into one of the USB ports, located just under the driver's arm rest, and the car can create a Wi-Fi hotspot and can also have its own WEP encrypted password for security.

Smart Phone tethering:

An Internet-capable smartphone can actually be used as a source for wireless connection instead of a USB modem. Cars can make use of the 3G/4G data plan of the smartphone by just connecting it to the car using a USB cable or Bluetooth.

LTE:

LTE is ultra-fast 4G/Long Term Evolution (LTE) networks. It provides mobile ultra broadband internet access even faster that 3G networks. It is a standard for wireless communication of high-speed data for mobile data terminals like automotives. Hardware for the car hotspot LTE is a LTE capable SIM card which is inserted into the hotspot, network infrastructure, LTE modems, advanced antennas, and piles of routers. It can then send 3G or 4G signals to up to eight Wi-Fi devices, and pairing can happen via a PIN or NFC chip. Its major advantage is its speed which is higher than other wireless technologies.



2. NEED FOR INTERNET ACCESS IN CARS:

Internet connected cars are a mobile platform where information can be easily accessed and transmitted through the **use of high bandwidth connectivity and cloud-based applications**.

3. CLOUD IN CARS:

The cloud is widely used by navigation applications, and is gaining acceptance with online music services. With cloud services, a small application on the head unit runs the HMI, while the application itself runs on the service provider's servers as shown in fig3.

Advantages of cloud in cars:

· New services can be added at the back end without needing to touch the vehicle.

· Users maintain control of their systems, subscribing to services or unsubscribing from them as desired.

· Interoperability between the vehicle head unit and portable devices enables "drop-and-drive" implementations. That means user can transfer apps, documents, music files using the drop and drive mechanism.

· Costs can be reduced because, with the almost limitless computing resources of the cloud available, cars need less powerful CPUs and less memory.

Why to use cloud in cars:

Music:

The ability to connect to streaming radio. Users can easily access their cloud-based music libraries.

Information:

Passengers can access a wide variety of real-time information from in-car telematics, including sports, news and weather.

Navigation:

Old navigation systems had relied on an internal hard drive or DVDs to store maps and other navigation information.

Home Control:

Direct connection from the concept of car to home automation and security systems.

Enhanced Communication Services: Calls and messaging services with a hands-free experience.

Factors that should be considered for deployment of cloud in cars:

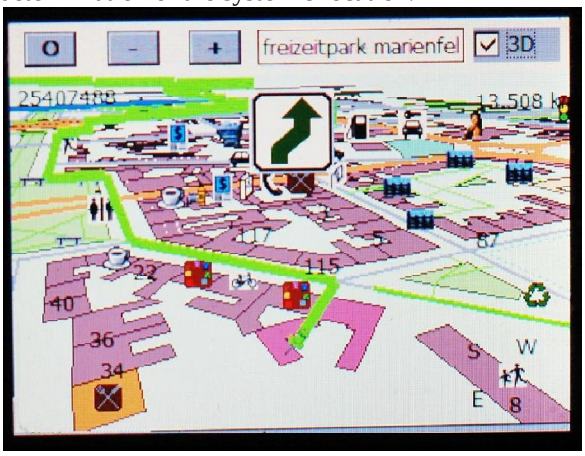
· Portability
· Computing power
· Connectivity
· Interoperability
· HMI
· New applications and updates
· Power

C. ADVANCED DRIVER ASSISTANCE SYSTEMS

ADAS (Advanced Driver Assistance Systems) came into being as a means for avoiding the increasing number of road accidents. ADAS includes many advanced features. Some of them are as given below:

Automotive Navigation Systems:
Automotive navigation system is used in in-vehicle infotainment (IVI) systems. Automotive navigation system uses satellite navigation technique. Navigation systems use top view for the map. These systems use global positioning system (GPS) to facilitate intelligent navigation.

1. GLOBAL POSITIONING SYSTEM (GPS):
GPS is used to find the systems current position. It helps in determining the co-ordinates (longitude nd latitude) of the system's position. These co-ordinates are mapped to the unit maps database which helps in determination of the system's location.



Global Positioning System

The diagram above shows how different numbers are associated with different location areas. So when the bicycle would head to that area it would return those position numbers and map with the units database in order to retrieve the present position of the system. In other words the Global Positioning System (GPS) gives the location of the automotive system on the earth as stored in the units database. The GPS device consists of a GPS receiver along with the navigation software suite. The database which is used to retrieve the location of the system is the Road Database.

Points of Interest:
The points of interest are stored in accordance with the attributes of nodes and links. . Even the shape of this POI is given to give a realistic top view of the area. It includes details of food outlets, popular locations, petrol stations etc.

Incremental Update of Maps Database:
The Maps database needs to be updated about the geographic locations and new points of interests. Since there are IDS in the maps database, so when they are updated, the ids with the existing database changes. To overcome this disadvantage the following approaches are adopted:-
On-board Compiler: The database in interchange format is transmitted to the vehicle. The changes comprise of:
· Additions
· Deletions
· Replacement
These changes are applied to the existing database. The interchange format is decompiled at run time. The combined database is compiled at runtime which involves assigning ID's.
Look-Aside Store: Basic changes are stored in the look-aside store other than being transmitted to the vehicle. The changes are reflected in the store every time the database is accessed. Due to this reason the navigational algorithm gets complicated.
Geographical Tiles: The map is broken down into geographical tiles. These tiles have a side of around 1 km. These tiles have a set of attributes associated with it. So every time there is a change the corresponding tile is sent to the vehicle. Sending these tiles is easier and more efficient as compared to look-aside buffer and onboard compiler. The disadvantage in this method is that when the attributes of a particular tile changes it distorts the structure and attributes of the adjacent tiles.
Integration and Other Functions: The same LCD screen used for automotive navigation can also be used for
· Gaming
· Watching videos/movies
· Internet surfing
· Reading text messages
· Display television broadcast

2. TRAFFIC MESSAGE CHANNEL (TMC):
It is a mechanism by which real time traffic information can be delivered to the user. TMC data is integrated within the automotive navigation system. This makes real time data available at the user's end.
Each traffic incident is binary encoded. Each message consists of an event code, location code, expected incident duration, affected extent and other details. These are used to describe situations like a crash, road blockade, traffic flow etc. Sources of this information include police, traffic control centres, camera systems, traffic speed detectors, floating car data, winter driving reports and roadwork report. It uses FM RDS system or satellite radio for transmission of TMC messages.

3. *AUTOMATIC CRUISE CONTROL SYSTEMS:*
ACC system automatically adjusts and controls the speed of the vehicle in order to maintain safe distance from the surrounding vehicles. It is a key component of intelligent cars in future. It makes decisions using sensor information from on-board sensors. It can make use of laser or infra-red sensors.

It has two major advantages:-
· Ensures safety of the driver and helps avoid accident.
· Economizes road capacity intelligently.

4. LANE DEPARTURE SYSTEMS:
This warns a driver if the vehicle moves out of the lane marking. These systems came into existence in order to avoid accidents.
There are two types of systems:-
· It alerts lane departure to the driver
· It alerts lane departure to the driver and if the driver does not take the necessary action it takes the necessary steps to ensure the vehicle remains within the lane.

D. SECURITY
1. DETECTING UNAUTHORIZED INTRUSION INTO YOUR CAR:

One of the systems that were used to detect intrusions in earlier days were 'Door Sensors'. These sensors work the same way that the doors of our refrigerator work. When we close the door of our refrigerator, a spring activated button gets pushed or compressed. On the compression of this button, the circuit that lights up a lamp in the refrigerator is broken and the lamp turns of. When we open the door again, this circuit gets completed again and the lamp is turned on.
The same principle is used in 'Door Sensors': When one of the car doors is opened, a small light bulb inside the car goes on. This bulb remains on, till any of the doors is open. Door sensors use the same part of circuitry that lights up this small bulb. Whenever one of the doors is broken into by an intruder, an electric current is set up inside the circuit which is used to turn on a siren or an alarm that starts ringing. This scares the intruder away.

Infotainment Based Intrusion Detection Dystems:
What we need in this system is basically a siren or alarm that goes on when someone tries to intrude the car by breaking open the glass windows. . The most common glass-breakage detector is a simple microphone connected to the brain of the Infotainment system. Microphones measure variations in airpressure fluctuation and convert this pattern into a fluctuating electrical current. The microphone converts this to an electrical current of that particular frequency, which it sends to the Infotainment system. The crossover is configured so that it will only conduct current that has the frequency of the sound of a breaking glass. In this way, only this specific sound will trigger the alarm, and all other sounds are ignored.

2. TRACKING A STOLEN VEHICLE:
Tracking of stolen vehicles is done using a Global Positioning System, familiarly known to all of us as GPS. We have already seen about the integration of a GPS into an Infotainment system. Now we see how GPS could be used to track a stolen vehicle.
The GPS system: The GPS system has 3 modules, a space module, a control module and a user module. In the space module, we have 4 geo-stationary satellites that orbit around the earth. These satellites are controlled and funded generally by a country's defence department. The control module is a receiver inside the car that can detect signals sent from these satellites.
The user module basically has functions that assist a user. For ex: Getting a route from your current location to the target destination.
Tracking: Using GPS, the location of a vehicle can be tracked up to a range of 10-15 meters. The four satellites and the receiver inside the car can be used to pinpoint the exact location of a car that has been stolen. The Infotainment system is so designed so as to send an SMS/email to the owner regarding the location of his vehicle every few hours. The owner can thus work in tandem with law enforcement agencies to track down his stolen car.
Disadvantages of GPS based Tracking: The biggest disadvantage is the blockage of signal transmission by obstacles such as mountains, high buildings, tunnels, etc. Multipath signals generated by reflections from nearby surfaces or fences can also interfere with the GPS data. So we need an alternate method that can overcome these disadvantages. In Infotainment systems, we use a combination of GPS with a technology called as 'Dead Reckoning'.
Dead Reckoning: Dead reckoning is accomplished by monitoring your speed and direction and using this data to keep track of your position relative to a known starting location. For ex: My current location is (x1,y1). After travelling a certain distance in a certain direction, after calculating the distance travelled and the direction of travel, the coordinates of a new location can be calculated say (x2,y2) .
Different techniques can be used to measure speed and distance when GPS reception is lost:
· accelerometers to sense changes in your speed and direction.
· sensors that measure the distance covered by the car's wheels.
The effectiveness of dead reckoning depends on how accurately a navigation system is able to monitor your speed and direction. Thus DR helps in estimating a new position based on what information it has about a previous location. DR combined with GPS is an excellent technology that can assist the tracking of stolen vehicles.

CONCLUSION

IVI has come a long way since the car radio and yet has a tremendous scope in future. Consumers now demand seamless connectivity for their phones and devices, along with a unique infotainment experience

for everyone on board. IVI provides the customers with the same digital lifestyles as they enjoy at their homes and offices. Besides access to applications, a car will also have advance navigational and driver assistance services like collision avoidance, autonomous cruise control which are improving on a daily basis. Sensors will combine information from various inputs and help drivers to avoid accidents with warning and control capabilities.

Remote maintenance plays a big role in security. Remote diagnosis can allow manufacturers to reset an electronic process in car, run a diagnostic app to identify issues and organize for necessary repair.
Soon we all would be in a world of smart vehicles and all this is possible because of in-vehicle infotainment systems.

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