1. INTRODUCTION

What is navigation? From, time immemorial human beings relied on natural signpost and the position of celestial bodies to find the desired route. As the population increase the need for better transportation increase. With the increase in automobiles came the problem of traffic congestion. This led to research in the field of navigation engineering. This brought about a wave of technological breakthroughs.

In this report I have included the major navigation systems such as GPS aided navigation system, two-dimensional vehicle tracking using video image processing, the position location arid reporting system used by the US Army and Marine Corps. Neural networks structure can be used to automate high way driving.

2. AN INFORMATION STRUCTURAL MODEL OF VEHICLE NAVIGATION AND ITS IMPLICATIONS

This paper proposes a simple model to provide a framework for investigating human behavior with vehicle navigation aids. This model consists of planning, decision- making, control, and perception. Decisions are made by comparing perceived cues from the outside view with the expected cues from planning. VNA assist mainly in dynamic planning, providing support and updating to the cognitive map, navigators have of their environment.

VNA aims at assisting drivers in car navigation; human capabilities and limitations have to be incorporated in VNA designs. To date research in vehicle navigation has not provided sufficient models to support such designs. There are many aspects of vehicle navigation with VNA have not been intensively addressed with models. The interactions between the human driver, the machine and the natural view of the environment is one of them.

A VNA system is assumed to have at least the following Characteristics

1. It has a database of navigation information. The database provides geographical and other relevant information about the area that the vehicle is traveling through.
2. It has a capability of locating the current position of the vehicle.
3. There is an algorithm making dynamic suggestions on route selection.
4. It has an interface, which presents the navigation model to the human driver.

A MODEL IN TRADITIONAL VEHICLE DRIVING

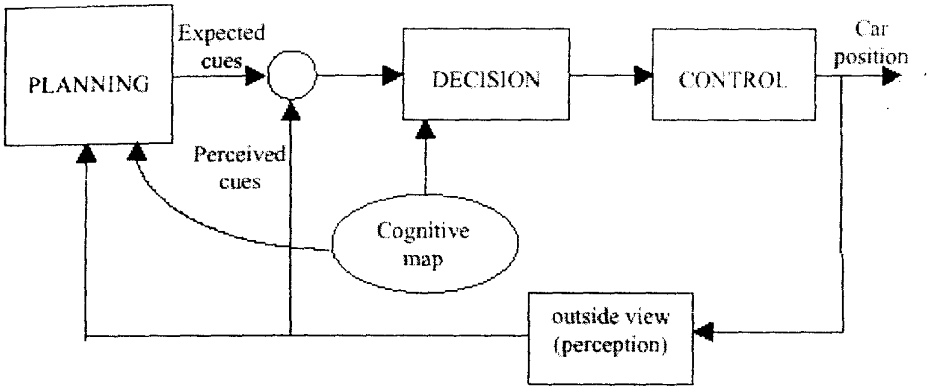


Fig. 1. Navigational model without VNA

Fig. 1 shows the basic activities and their information relations in traditional car driving without VNA. The human driver constantly observes the environment catching a variety of cues, such as road signs, trees and buildings. The perceived cues are then compared with the expected cues in driver's memory. The expected cues are created from the drivers planning activity. When the driver cannot match the perceived cues with the expected cues for a period of time, he/she is loosing his/her orientation. There are two basic characteristics of expected cues.

1. These cues are not necessarily clearly recalled information instead; they might be vague information in the driver's memory. The driver may not be able to precisely predict the next view. But he can expect some features that can be recognized when they are seen.
2. These cues are basically discrete. Drivers do not necessarily constantly expect navigational cues instead they take heed of 'landmarks' as needed.

In traditional car driving both planning and decision- making are based on a cognitive map, the driver's mental model of the external world he is moving through. The perception component has to provide two kinds of information: Navigational cues mentioned above are guidance cues such as vehicles on the road. To compare and integrate expected cues with the perceived cues could also be difficult.

MODEL WITH NAVIGATION AIDS

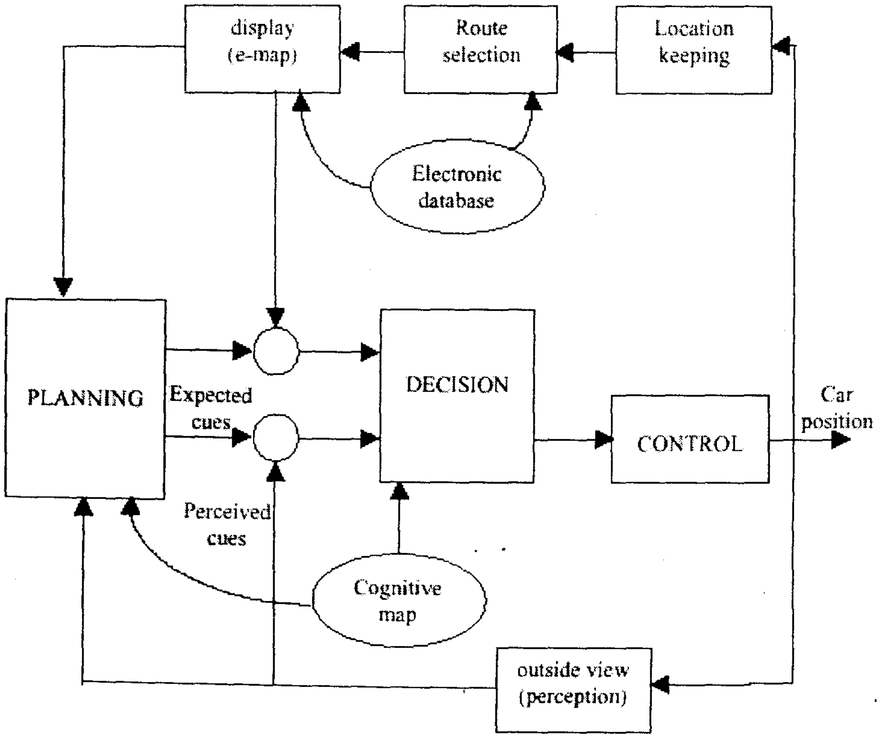


Fig. 2. Navigational model with VNA

Fig. 2 presents the information structure of vehicle navigation activities with VNA. In addition to the components in figure 1, another four basic VNA functions are added in this model. The route selection algorithm in VNA makes suggestions according to the electronic database and current vehicle location. The suggestions and instructions from VNA are presented to the driver through the display interface. In this new scenario, both planning and decision processes are based on two channels:

1. Natural view system, supported by the driver's cognitive map.
2. VNA display supported by an electronic database.

The information from the VNA channel will greatly reduce a driver's dependence on his cognitive map. Suggestions and instructions form VNA should change dynamically according to the vehicles current position, which is the result of the interactions of the driver, machine and the environment. The human driver has to integrate natural cues and navigational aids. The orientation of the electronic map should be in accordance with the vehicle's heading.

3. DEVELOPMENT OF ADVANCED DYNAMIC NAVIGATION SYSTEM

The dynamic navigation system is an information providing type navigation and route guidance system. Fundamentally the system is suited for phased implementation. In the information providing system, travelers can obtain traffic condition information and determine travel routes at their own discretion. Thus it may satisfy travelers more than an infrastructure oriented perceptive system, thus achieving a higher acceptance ratio for the information provided.

OUTLINE OF THE SYSTEM

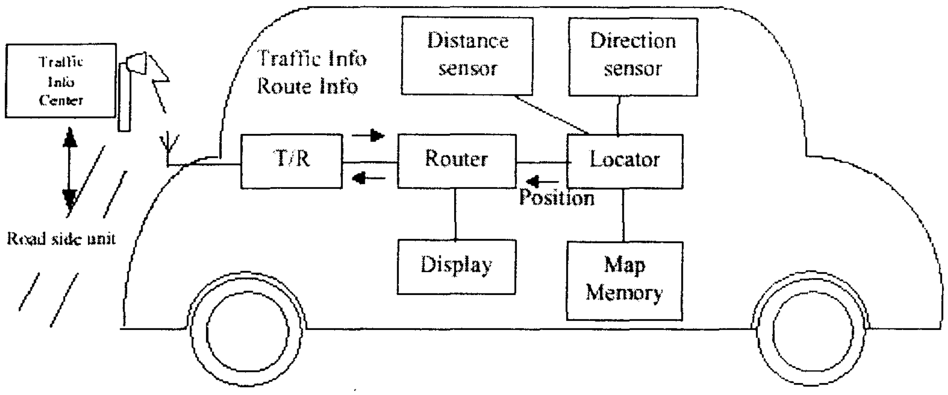


Fig. 3. Dynamic Navigation System

Fig. 3 shows the complete composition of the dynamic navigation system. The on board equipment consists of a transceiver, a router with a display, and a locator with sensors and a map memory. Locator tracks the position of the vehicle. The router calculates an optimum route based on the traffic data received by the transceiver and the road network stored in the map memory. The router determines the turning direction at intersections knowing the position of the vehicle and the neighborhood geometry. The roadside equipment sense graphic information and position data to correct any navigation error and may receive travel time data from the vehicle.

PHASED APPROACH

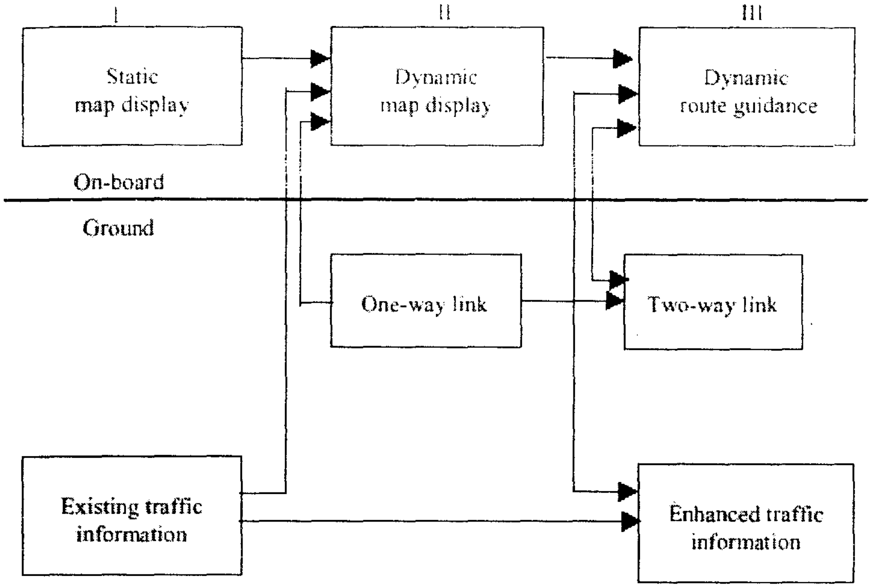


Fig. 4. Phased approach

The onboard equipment is provided with the traffic information from the ground, indicates it on display calculates an optimal route and guides the traveler. Using these functions, the traveler can know an overall route before starting, change route-finding criterion, as he likes. In the first phase (Static Navigation System), a stand-alone navigation system uses only onboard information. In this phase the system has a CD-ROM map database and is able to detect its location and display the present location and destination in the map by itself. It functions without any assistance from the ground and can operate with only one vehicle. In the second phase (Basic Dynamic Navigation System) the stand-alone navigation is provided with traffic information, which exists in the control centers.

The information is rather qualitative such as degree of condition, insufficient to calculate the optimal route and hence used mainly for display on the map. To realize the second phase only a one-way communication link from the ground to the vehicle is required. The third phase (Advanced Dynamic Navigation System) is to make the communications link bilateral. The on-board equipment transmits to the ground, traffic information such as travel time measure on each road segment. Roadside equipment provides the vehicle with valuable and quantitative information such as process travel time which is collected and predicted using both onboard and control center data. The on-board equipment calculates an optimal route based on the traffic information and driver's pre-entered route finding criterion, and then carries out route guidance.

To make the system bilateral, several items must be considered aside from the addition of an up-link, which makes the system bilateral. These items are:

1. Flexible data composition for information providing.
2. Travel time measuring function by an onboard equipment.
3. System configuration to minimize system delay for information collecting and providing.
4. Provision of predicted traffic information.
5. Pursuit of user optimization and system optimization.

The system studied supposes that the ground vehicle network is bilateral but monologue and has spot communication zones such as proximity beacons located intermittently

4. INTEGRATION OF GPS AND DEAD RECKONING NAVIGATION SYSTEMS

Dead Reckoning Systems and GPS are two commonly used techniques for vehicle navigation systems. While both model suffers from different drawbacks. Superior performance can be obtained by combining these two techniques.

In these systems, vehicle positions are acquired by using onboard or externally installed sensors like odometers, compasses, gyroscopes, radio-frequency receivers, etc. The road network is digitized and complied into a geographic database and stored on a CD-ROM or a nonvolatile memory. As the vehicle travels the vehicle location on the road network is displayed on line on an electronic digital map. In order to guide users with proper Maneuver instructions, the vehicle location must be precisely determined. If the vehicle location cannot be pinpointed, all subsequent maneuver instructions generated by the system will become useless and the whole purpose of route- guidance will be defeated. Therefore accurate vehicle positioning is a pre-requisite for the good performance of automotive navigation and route guidance systems. -

Dead-Reckoning method is an often-used vehicle positioning technique. In this method, heading and distance sensors are used to measure the displacement vectors, which are then used in a recursive manner to determine the current vehicle position. Accuracy of the dead reckoning method, however, is constantly degrading since errors in all measurements accumulatively affect the current position estimation. For vehicles traveling on the road network, map-matching technique is often used to correct the positioning errors. In this method the vehicle traveling path is constantly compared with the road network. Through pattern recognition and matching process, the most likely location of the vehicle with respect to the map is determined. However in urban areas with dense road networks, map matching method may have difficulties in picking out the correct vehicle location from many streets that have similar geometric shapes.

The Global Positioning System (GPS), through the use of satellites as the reference positions, provides absolute vehicle positions without the error accumulation associated with the dead-reckoning systems. However, the satellite geometry, Selective Availability (SA), and environmental effects affect its accuracy and availability. The GPS signals in this system are used in on-line adaptive sensor calibration algorithm to minimize the accumulated Dead-reckoning errors. The information from the dead-reckoning system, combined with map matching algorithm is used to minimize the GPS measurement errors, which may be resulting from the change of satellite geometry and the signal noises.

DEAD-RECKONING SYSTEM

For vehicles travelling on a two dimensional planar space, it is possible to calculate the vehicle position at any time instance provided that the starting location and all subsequent displacement vectors are available. Mathematically, the vehicle position (X_k, Y_k) at time t_k can be expressed as

$$X_k = X_0 + \sum_{i=0}^{k-I} + S_i \, COS\theta_1 + \sum_{i=0}^{k-I} S_i \, Sin\theta_l$$

Where (xo, yo) is the initial vehicle location at time to, and S_i and θ_1 are respectively, the length and absolute heading of the displacement vector from the vehicle position (x_i, y_j) at time t_i to (X_{i+1}, y_{i+1}) at time t_{j+1}. The relative heading (bearing) is defined here as the difference between absolute headings at two consecutive instances and is denoted as ω_i. in Fig. 5

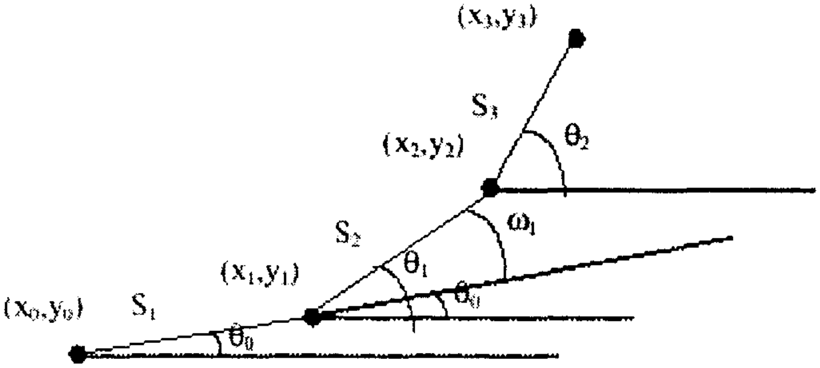


Fig. 5. Dead-reckoning method

Given relative heading measurements ω_i for time to, $t_{1,.....,}t_{k,}$, the absolute heading of the vehicle θ_k at time t_k can be calculated from

$$\theta_k = \sum_{i=0}^{k} \omega_i$$

As shown in equation 1 the dead reckoning method is an accumulative process. Consequently, all previous sensor errors accumulate and degrade the accuracy of the current calculated position. In automotive navigation systems, wheel odometers and accelerometers are used to measure the traveled distance. Compasses, gyroscopes, and the differential odometry techniques are used to measure the vehicle heading. -

WHEEL ODOMETERS

Wheel odometers measure the vehicle traveling distance by multiplying the number of pulses, electronically generated by the rotating wheels by a constant, which depends on the perimeter of the wheels. Factors such as vehicle speed, tire pressure, vehicle payload, tire tread wear off, etc. all affect the actual tire size and thus the distance measurement accuracy.

The difference between distance measurements from both the left and the right wheels when it is small is in proportion to the relative heading. This property makes the odometers useful for measuring the vehicle heading as well. In reality, however, the measurement accuracy of relative heading is affected by the distance measurement errors. However difference exists between left and right wheel distance measurements. The distance difference translates into a drift in bearing measurement even when the vehicle is traveling on a straight road. Using the bias bearing measurements, the dead-reckoning trajectory eventually arrives at a distant point that is significantly different from the point of destination. This drifting phenomenon is a major error source for the dead-reckoning systems using differential odometry.

FLUX GATE COMPASS

Flux gate compass uses a pair of perpendicular coils to measure the direction of the magnetic field. By measuring the vector direction formed by the two coil voltages, the direction of the magnetic field can be determined. Since the vehicle is a steel structure, the actual magnetic field direction, measured by an onboard compass is really from the combined magnetic field formed by the earth and the vehicle itself. The accuracy of the compass measurements is thus affected greatly by the degree of vehicle body magnetization.

A commonly used method to calibrate the magnetization effect is to turn the vehicle for 360 0 and obtain the minima and maxima for both coil voltages to identify the center of the magnetization circle. In addition, the vehicle magnetic field may be affected by steel items carried on the vehicle, the electrical current generated by onboard electrical devices etc. These magnetic anomalies produce short term, high frequency noise in compass measurement. Depending on the magnitudes of magnetic anomalies, this randomly jumping phenomenon becomes more serious.

GYROSCOPE

Gyroscopes measure the angular velocities of the vehicle. For a constant sampling rate, the angular speeds are in proportion to the relative headings. Therefore, gyroscopes can be used similar to the differential odometers to measure the relative headings of the vehicle. However, gyroscopes suffer from the drifting problem resulting from change in operating temperature. A long period of warm-up time is required before gyroscopes can work properly. In addition, due to A/D conversion and quantization errors, gyroscopes have more difficulties in measuring small angular velocities where the vehicle was driving on freeways, where most turns have large radii of curvature. The errors in gyroscope measurements produce drifting problem similar to the differential odometers.

GPS NAVIGATION

The Global Positioning System (GPS) is a satellite based radio navigation system developed by the US Department of Defense. The satellite orbits will be arranged so that a minimum of 5 satellites is visible to the users anywhere in the world at all times. The GPS receiver uses signals from a set of at least 3 or 4 satellites (respectively for two-dimensional or three dimensional navigation) that forms the best satellite geometry, and calculates the distance between the receiver and the satellites. Given the distance measurements (called pseudoranges), user positions with respect to earth's inertial co ordinates can be obtained.

Accuracy of the GPS position measurements depends on the satellite geometry which is usually measured by the dilution of position (DOP), as well as other factors including ephemeris uncertainties, propagation errors, timing errors, multiple signal propagation path and receiver noises.

Authorized users will be able to obtain absolute position information with accuracy at about 30 meters RMS error through the Precise Positioning Service (PPS). The Standard Positioning Service (SPS) will provide position information to all users, but with accuracy degraded to the range of 100 meters RMS error, through the use of Selective Availability (SA) technique, which adds noise to the pseudoranges measurements and varies the ephemeris data broadcast from the satellites. The RMS error, including both 2-D and 3-D navigation, is about 120 meters, with instantaneous position errors as large as 1800 meters for 2-D navigation.

GPS indeed can deliver position information within 30 meters RMS error. However it also demonstrates that unexpected effects and large position errors may arise when the GPS satellite geometry and visibility are less than perfect. For road vehicles that constantly travelling on urban areas where tunnels over passes, tall buildings and trees are abundant, perfect reception condition is rarely possible. Even, when there are enough satellites available for position calculation, the satellite geometry may not be good enough to yield accurate position measurements. In addition, serious multipath problems may happen when the satellite signals bounce off building walls before reaching the receiver.

INTEGRATION OF SENSOR SYSTEMS

As discussed earlier, the dead reckoning system suffers from the error accumulation problem. Although map- matching technique can be used to provide some forms of absolute position feedbacks to correct the errors, in dense street areas where high degree of ambiguity exists in the map-matching process, this becomes very difficult. On the other hand, GPS provides absolute position information free from any error accumulation. However, the GPS signal is easily deteriorated by tall buildings and trees that are common in most urban areas. With SA being implemented, situation may even worse as 100 meters RMS error may be inadequate for land vehicle navigation purposes.

It becomes clear that a superior positioning system exists if the advantages of the dead-reckoning systems and the GPS can be combined together. The absolute position accuracy of GPS can be used to provide feedback signals to correct the dead- reckoning errors. While the smoothness and constant availability of the dead-reckoning signals can be used to correct the errors of the GPS position signals due to SA effect and multi-path problems.

The integration is usually done either through a switching algorithm that switches from one system to the other if the latter has better signal condition, or through a Kalman filtering approach that combines all sensor information (along with their uncertainty to form a better estimation). Given the availability and accuracy problem of the GPS signals, the integrated system uses dead-reckoning method as the major Positioning technique. When GPS signals are available, they will be used not only to correct the drifted dead-reckoning position, but also to calibrate the dead-reckoning sensors. When the GPS is not functioning well, the calibrated dead reckoning system will provide better performance than before. In addition to overcome the GPS positioning errors, the GPS positions are constantly calibrated by using the map-matched position. Then, for a brief GPS signal lost (such as passing through a tunnel), the newly acquired GPS signal will be as accurate as possible. This adaptive approach provides an ever-improving system performance even with temporary absence of GPS signal.

GPS AIDED INITIALIZATION

One big problem in using the dead-reckoning system is the need for accurate initial vehicle location before the system can function correctly. This initialization process is not only tedious but may be impossible at some situations. For example, the vehicle may start travelling form a large parking lot and it would be difficult to pinpoint the stating location. With GPS signal this initialization procedure can be automated. If the vehicle is in an underground parking structure, the last dead- reckoning position can be used as the initial vehicle position. However, as soon as they become available, the GPS signals can be used immediately to correct the vehicle location.

GPS AIDED ERROR RECOVERY

All navigation systems, no matter how well designed will have some unexpected positioning errors. When the map- matching algorithm fails to make correct decision and the dead— reckoning systems gets lost. The user will need to enter his current position as the new initial position and start again. With the GPS absolute position, this procedure cannot only be automated but also be avoided completely. When the dead- reckoning/map-matching algorithm has uncertainty about its estimated position, the GPS position can always be used to double shift the current position and to confirm the decision.

GPS CALIBRATION ALGORITHM

A performance index to measure how well a dead reckoning/map matching system performs is to compare the dead-reckoning position with the map-matched position. If the two agrees with each other frequently, it is likely that the dead- reckoning system has high accuracy. Using this principle, the map-matched dead-reckoning position can be used to correct the GPS position error adaptively when the dead-reckoning system has good performance. The GPS error will then be reduced gradually to the level of the database error.

5. POSITION LOCATION AND REPORTING SYSTEM (PLRS)

Highlights of the capabilities of the Position Location and Reporting System (PLRS) are presented in this paper. Emphasis is placed on the users' role in the system and the development of the equipment for the user.

The major elements of PLRS and their interactions are discussed. The PLRS user equipment family is based on a common Basic User Unit (BUU) for man-pack, surface vehicle and airborne applications.

The PLRS user equipment includes the Basic User Unit, the User Readout module, the Portable Test Unit, the Command Response Unit, the Pilot's Control Display Panel and various power sources, antennas and installation kits. The PLRS user equipment family is based on the heavy use of the RCA, CMOS 1802 microprocessor in conjunction with several custom designed LSI circuits. A functional block diagram of the PLRS Basic User Unit is presented.

PLRS will provide the Army and Marine Corps with a unique range of capabilities, which will, in many respects revolutionize the conduct of battlefield operations. The capabilities are summarized in table 1. For the individual tactical user the system determines and displays to him his accurate position in three-dimensions in real time. On request, it provides hint with the bearing and range to other locations or friendly units. It guides him automatically on predesigned routes or three-dimensional corridors, and alerts him if he crosses a boundary or enters a restricted area. The system network consists of up to 370 actively tracked users per community. The system has the capacity for processing approximately 50 position updates per second with varying update rates for different user types. For all participants, the system (which operates beyond line-of-sight via, integral relays) incorporates effective electronic counter-counter measures (ECCM) and provides secure digital data communication. Each user has the capability of sending three assigned two character messages to provide data to or request information form the system, as well as 12. Character free text message inputs. Its configuration ensures continuity of operation under all kinds of visibility whether and terrain and during the transition of tactical headquarters. It allows for Survivability even if a major system element becomes inoperative. It can inter-operate with at least 4 other PLRS communities in adjacent geographic areas. The System performance is provided within a 47-km by 47-km primary operating area.

MAJOR ELEMENTS OF PLRS

PLRS employs two categories of hardware, Master Unit (MU) and User Unit (UU) to provide the capabilities described above. The two forms of hardware operate in a synchronous Time Division Multiple Access (TDMA) network structure with frequency hopping.

The PLRS Master Unit (MU) performs the functions of centralized network management, automatic processing of position, and navigation and identification information for each participating user. User Units (UU5) which are individually identifiable to the MU, perform reception, transmission (including relay), range measurement, and various signal and message processing functions necessary for position location and communication operations within the system.

A PLRS community is deployed with two identically equipped MUs, one of which is designated the Alternate Master Unit (AMU). The AMU monitors the MU's operation, participates in network position location and communication functions, and assumes system control either when directed by the MU operator or automatically up on MU failure.

Requirements	Features
Position location	— Real time — Accurate Automatic display — Three dimensional
Navigation Aid	— Bearing and range — Corridor guidance — Boundary penetration alerts
Identification	— Automatic with position location — All weather and all visibility conditions
Communications	— Secure — Non line-of-sight (Relay capability) — ECCM
Tactical Utility	— High capacity (Large No. of units) — Flexible — Survivable Rugged and light weight — Simple to operate and maintain

Table 1. PLRS operational capabilities

The identification and position determination of UUs by PLRS is fully automatic I e when the UU operator turns on his equipment, it automatically becomes and remains a member of the PLRS network However to permit the UU operator to provide data and request to the MU and to receive and display information from the MU, a separate user I/O device is required and is usually employed with each UU

The system design is characterized by a single integrated waveform and a fully synchronous time ordered network structure. The use of microprocessors in the UU design increases system flexibility.

PLRS USER EQUIPMENT FAMILY

The Basic User Unit (BUU) contains the principal transmit, receive, signal and message processing elements, which are used in all the various UUs.

FUNCTIONAL HIGHLIGHTS

The UU provides all the functional capabilities to communicate with the MU using PLRS messages. The UU provides for digital data transfer between the UU operator and MU. It can interface with external specific data devices through the User Unit's I/O interface. The User Unit is capable of making accurate range (Time of Arrival) measurements and provides integral relay capability.

The UU operation is controlled by a low-power CMOS Microprocessor, which accepts, interprets and acts on MU- Originated commands. The microprocessor schedules and controls all of the UU processes. It schedules the unit to: transmit; receive; acquire network synchronization; measure signal time of arrival (TQA); send status; relay data; originate or receive data messages; control power turn-on / turn-off internal Circuitry as required to minimize UU power consumption. The UU has an internal barometric pressure transducer to measure atmospheric pressure. The microprocessor periodically enables the transducer, stores the pressure reading, and forwards the data to the MU. The MU processes the pressure and converts pressure to altitude for each UU for altitude-aided multilateration using UU reported TOA measurements.

The MU

1. Transmits and receives PLRS messages.
2. Accepts, interprets, and responds to MU originated commands.
3. Adjusts RF power output under MU control.
4. Provides accurate TOA measurement.
5. Measures barometric pressures.
6. Has integral relay capability.
7. Originates and receives data input/output.

USER UNIT FUNCTIONAL DESCRIPTION

A functional block diagram of the PLRS basic user unit is presented in Fig. 6.

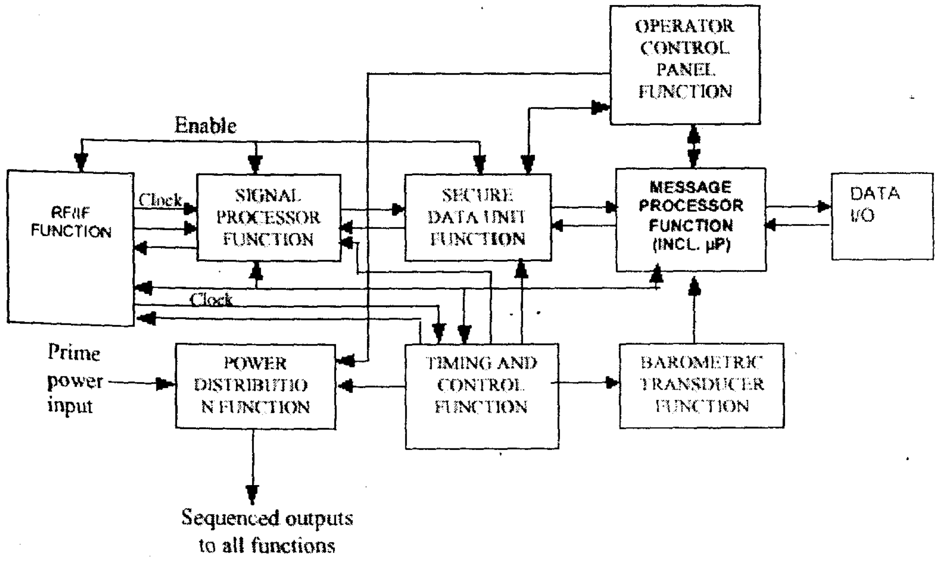


Fig. 6. PLRS Basic User Unit Functional Block Diagram

The following discussion of each UU function describes the processing aspects of the UU.

RF/IF FUNCTION

The PLRS RF/IF function performs frequency conversion, amplification and filtering of the transmitted and received signals. During reception this function also performs A/D conversion of the incoming signals in a two bit adaptive A/D converter, for subsequent digital processing by the Signal Processor function (SP). During transmission, the digital output of the SP is used to modulate the transmitted carrier. The UU crystal oscillator time base, frequency hopped synthesizer and local oscillators are all contained in the RF/IF function.

SIGNAL PROCESSOR FUNCTION

The signal processor function performs preamble detection / generation, interleaving / de-intedeaving, error correction/detection, encoding/decoding of received and transmitted signals. The SP interfaces with the RF/IF function and the Secure Data Unit function (SDU).

SECURE DATA UNIT FUNCTION

The secure data unit function encrypts/decrypts transmitted and received PLRS signals, provides message validation encoding/ decoding and alarm checking and provides data for control of the Signal Processor.

MESSAGE PROCESSOR FUNCTION

The Message Processor function (MP) contains a CMOS Microprocessor that controls the user unit This function controls and time sequences (along with the Timing and Control Function working as a slave) all other processes done within the User Unit The MP additionally generates, checks, composes, decodes, interprets and reacts to the PLRS message set The MPs microprocessor accomplishes most of the processing done by this function. A set of programs is stored in ROM. These programs direct the UU to conduct a large number of sequential operations (i.e. receive, measure, record, transmit, store, combine, etc) over and over again Thus the MU has the ability to place a UU in one of many modes with all other functions within the UU under the direction of microprocessor The MP also interfaces with the data I/O device which could be a URO or special data module

OPERATOR/CONTROL PANEL FUNCTION

The operator/Control panel function accomplishes the user unit to human operator interface required to enable power, load crypto variables, monitor operation of the UU, and interface with the antenna and data I/O devices.

BAROMETRIC TRANSDUCER FUNCTION

The Barometric Transducer function enables the UU to make measurements of barometric pressure and report this data to the MU, where it is converted to altitude information.

TIMING AND CONTROL FUNCTION

The timing and control function generates all time slot timing signals used within the UU. Additionally the T&C function generates all the sub-time slot signals, and the enable and disable control signals required by the UU as commanded by the MP function.

POWER DISTRIBUTION FUNCTION

The power distribution function contains the power supplies, regulators, power line filters and power switching (and sequencing) circuitry needed by the UU. This function is controlled by the T&C and operator/control panel functions and provide power to all the electronics within the UU.

FUTURE USES OF PLRS TECHNOLOGY

1. Test range instrumentation for position location, navigation and communication
2. Marine uses such as guiding a helicopter to an offshore oil rig in foggy or inclement weather.
3. Coastal confluence zone navigation.
4. Location and control of vehicles on the ground at large, congested, metropolitan airports.

6. TWO DIMENSIONAL VEHICLE TRACKING USING VIDEO IMAGE PROCESSING

In the field of traffic engineering, it is sometimes required to observe two-dimensional vehicle motions within a road section of several hundred meters to understand the traffic flow phenomena especially at capacity bottle necks such as at grade intersections, merging and weaving sections, etc. For this purpose video images have been used to measure individual vehicle motion. The measurement of vehicle position from the images, however, requires a large amount of time and effort.

CONFIGURATION OF HARDWARE

The hardware consists of a CCD camera, an optical magnetic disc, an image memory, an A/D converter, a D/A converter s a 32-bit microcomputer. The image recorded by a CCD camera is stored to an optical disc in which ever frame has an address so that we control image frames quickly as well as easily. The A/D converter converts analog video signals to digital image data of 512 x 512 pixels with a 8 bit (256 levels) intensity levels for each RGB color. A microcomputer (20 MHz, 32-bit CPU (80386)) is used.

There are two constrains on video images to be analyzed.

1. The image must be recorded by a fixed camera and
2. There ace no vehicle occlusion in the image.

HARDWARE ARCHITECTURE

Image processing equipment are compactly designed for all weather with high reliability so that they may be installed on the road side.

BASIC CONFIGURATION

Specially designed hardware has been developed in order to accomplish high speed image processing. The simple configuration and the processing sections were incorporated on a single board. Fig. 7 shows the block diagram of the basic configuration. The processing board comprises the pre-processor and the main processor. The pre-processor is an image processor and mainly carries out picture element operation as well as background difference and frame difference processing. To shorten the processing time, pipeline processing is employed. In order to accomplish this, dual port memories are provided which can be simultaneously accessed by both processors.

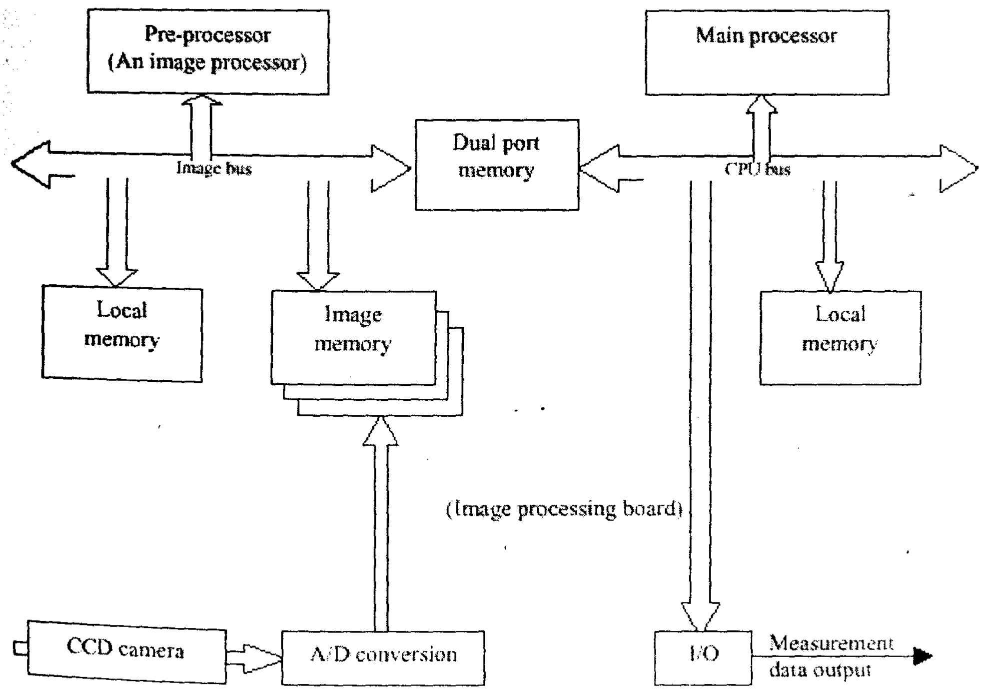


Fig. 7. Basic configuration

CONNECTION OF TV MONITOR AND CONSOLE

A monitor TV can be connected when adjusting the equipment or when performing maintenance work and an indication board can be easily mounted for checking image- processing results. Initialization of the measuring area can be easily accomplished using the monitor TV and mouse.

METHODOLOGY

Fig. 8 shows the flow diagram of the processing.

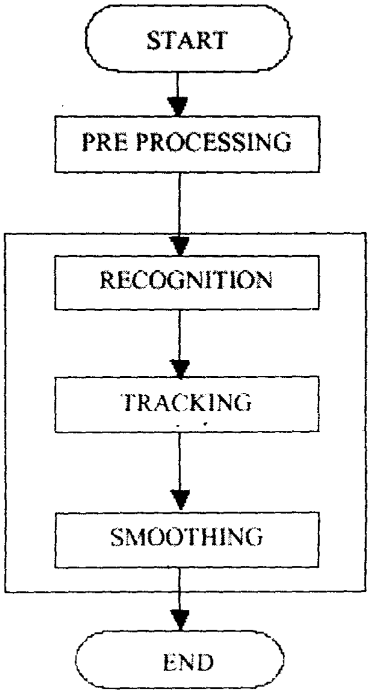


Fig. 8. Processing Flow

As in most of conventional methods, we use differences of intensity levels between the object image and the background image to extract a moving object Background image means the image without vehicle

PREPROCESSING

In the preprocessing, the study area and the inflow vehicle detection line are manually setup and the background image as well as the threshold of the intensity level are determined.

The background image is automatically obtained using a variation of intensity levels over time in each pixel, as in fig. 9. When a vehicle passes on a certain pixel its intensity level becomes unstable. Therefore a background intensity level of the pixel is taken as the mode value of the intensity distribution. The complete background image is obtained from the mode value of every pixel in the study area.

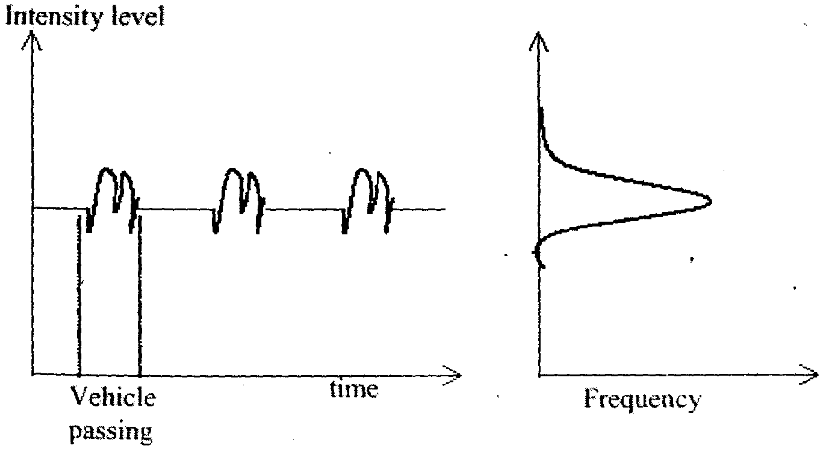
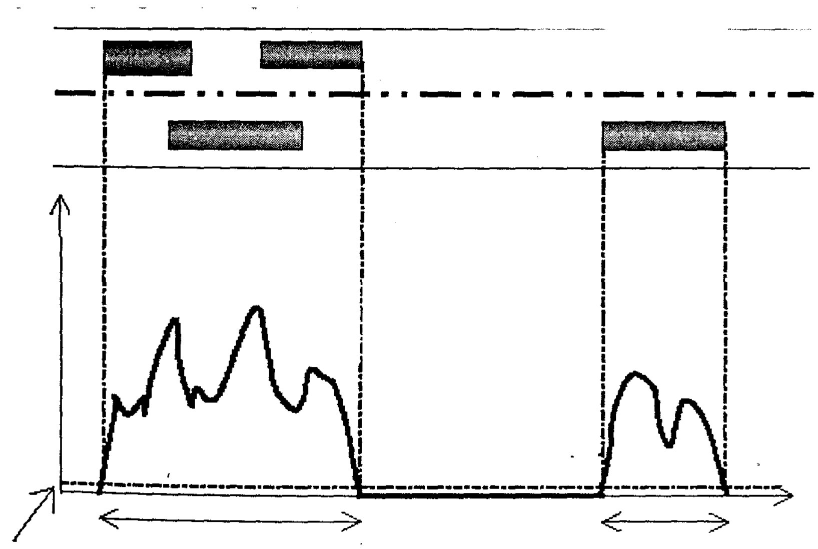


Fig. 9. Time –variance and frequency of intensity level on each pixel

RECOGNITION

Once the background image is acquired, subtracting the background image from the original image yields the subtracted image. For the subtracted images during a few seconds, the frequency distribution of absolute values of subtracted intensity is obtained. The peak around zero intensity represents the road surface and another peak shows the intensity difference between vehicles and the background. Therefore the threshold value for extracting vehicles is determined so as to maximize the ratio of interclass variance and interclass variance. The background image and the threshold value can be updated in a specified time interval depending on changes of weather condition.

RECOGNITION OF VEHICLE



Existence **Fig. 10.1.** **Existence**

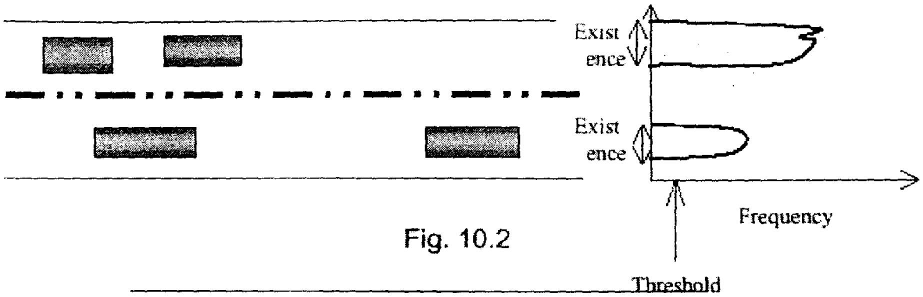


Fig. 10.2

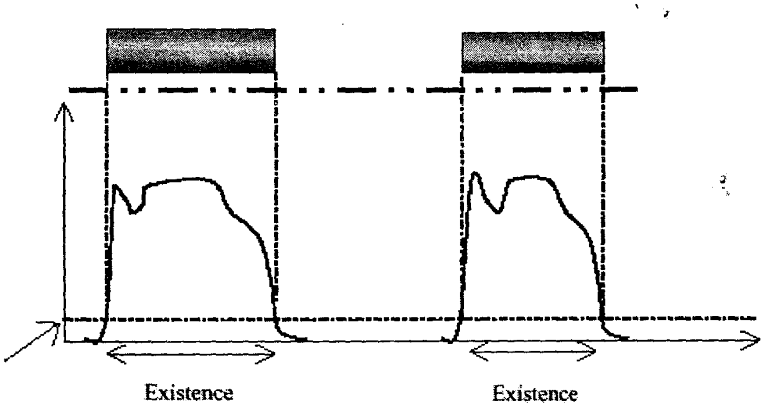


Fig. 10. Recognition Of Individual Vehicle

The subtracted image of the steady area is first obtained. If the absolute value of subtracted intensities is more than threshold intensity; it implies the existence of some object or noise in the pixel. Therefore the histogram of such pixel frequency is obtained over the lateral direction of the road as shown in Fig. 10.1. Sections with frequencies higher than a certain threshold (normally five) are expected to have some vehicles. In this way the area of vehicle existence is narrowed.

Then, within the narrowed area, the histogram of pixel frequency is similarly obtained over the, longitudinal direction of the road as in fig 10.2,and the area of vehicle existence is further narrowed. Finally, by drawing the histogram of pixel frequency laterally again as in Fig. 10.3, regions in which vehicles possibly exist can be extracted.

In this procedure if the size of an extracted region is found less than the prespecified vehicle length or width, the region is eliminated from the analysis.

The extracted region contains not only the vehicle, but also the shadow, which must be eliminated. Since intensity level of a shadow is generally lower than the background intensity, the subtracted value usually takes negative value. However this is not always the case because sometimes the vehicle has intensity lower than the background. For example a windshield glass with low intensity possibly has negative subtracted intensities particularly when it exists on a portion of lane marking having high intensity in the background. On the contrary, the region with high-subtracted intensity surely represents the vehicle existence. The intensity levels of edge between shadow and vehicle tend to be rather low.

To determine the edge between shadow and the vehicle, first, the histograms of positive and negative subtracted intensities are separately drawn: If we find the positive profile which continues below the specified threshold value (normally zero) to the end of the extracted region. We assume the existence of an edge between vehicle and shadow. Then determine the edge at a location with a minimum value of the corresponding negative profile. This completes the extraction procedure for vehicle.

Once a vehicle is extracted, individual vehicle parameters such as vehicle length, width,, intensity profile, and direction of motion. These additional information on each vehicle is stored as a tracking data and used for the next process.

TRACKING

Tracking means matching of individual vehicles from frame to frame by using the above tracking data. In the second frame from which a vehicle is recognized, we can estimate an area in which the same vehicle is expected to exist based on the direction of motion. In this estimated same size of region of the vehicle as in the previous frame is extracted on the subtracted image. Based on the stored intensity of the vehicle, we search a region of the same size within the estimated area so as to minimize the Root Mean Square (RMS) value of the subtracted intensity. Once the region is determined on a second frame, the velocity of the vehicle can be know by comparing the position with one on the first frame and the velocity is attached to the tracking data.

From the third frame, the estimated area can be reduced by utilizing both the direction of vehicle motion and its velocity. It makes the processing speed fast. Repeating this procedure until the vehicle goes out of the study area, a trajectory of the vehicle motion is obtained.

SMOOTHING

Through the tracking procedure, a trajectory of individual vehicle is acquired; however the trajectory may include some tracking errors to correct the trajectory the Kalman filtering algorithm is employed in this study. The algorithm smoothens the trajectory taking into account relationship among the vehicle position, velocity and acceleration.

LIMITATIONS

The application of this system is however limited in this study. We have to especially examine how to determine the threshold intensity, the background image for various different conditions. Also we should relax the constrains on the video image; i.e., the system should be improved so that it can deal with video images recorded by a moving camera as well as images with vehicle occlusion.

7. NEURAL NETWORK APPROACHES

A Neural Network is a biological model of a human brain, simulated in the binary memory of your PC. It is made up of artificial Neurons, connected to each other by Axions. Each Neuron can have many inputs, but only one output. As a Neuron gets energized by input, it fires, sending energy along axions to other near by Neurons. If another Neuron receives energy from two or more axions, it also will fire, propagating the excitation to others. There are hundreds or even thousands of such Neurons, arranged in layers, and all together they form a Neural Network, capable of learning from experience. Neural Networks have been utilized in finding patterns in signals, performing image processing and recognition, robotics, optical character input analysis, and other types of pattern recognition.

While many approaches are possible to the design of a lateral control system, neural networks were studied for two principal reasons. First neural networks have been shown to be good classifiers of otherwise unrelated data. One approach to the automated driving problem requires that drivers view images be correlated to steering decisions. The images are but arrays of numbers that have a non-obvious relationship with physical parameters such as yaw angle and displacement from the centerline. If these physical parameters were readily available from the image data then standard physical dynamics and control models could be used to determine the optimal steering control. But these physical parameters are not readily available from the image data. One could use neural networks to correlate the image data with yaw and displacement. What one needs to do is to ‘train’ a neural network to properly relate image data to steering angle. The second reason is motivated by our own driving experiences. It seems doubtful that the brain first computes yaw and displacement and then solves some differential equation to determine steering angle as we drive down the road. The brain seems to directly relate the view ahead with how much we turn the wheel. Simply because the brain can do it does not imply that an artificial neural network can do it. Also some successes have been reported by using different controller designs.

CONTROLLER DESIGN

One can envision several controller designs within which the neural network paradigm can be implemented. The simplest is that of an open loop control in which the image is the input and the steering command is the output as shown in Fig. 11. While this is simple, it contains all of the disadvantages of such a control system, although it may still be acceptable if the lateral dynamic elements of nominal highway driving are 'small enough'. Extremely poor convergence properties and tends to forget earlier training patterns, severely complicates the training phase.

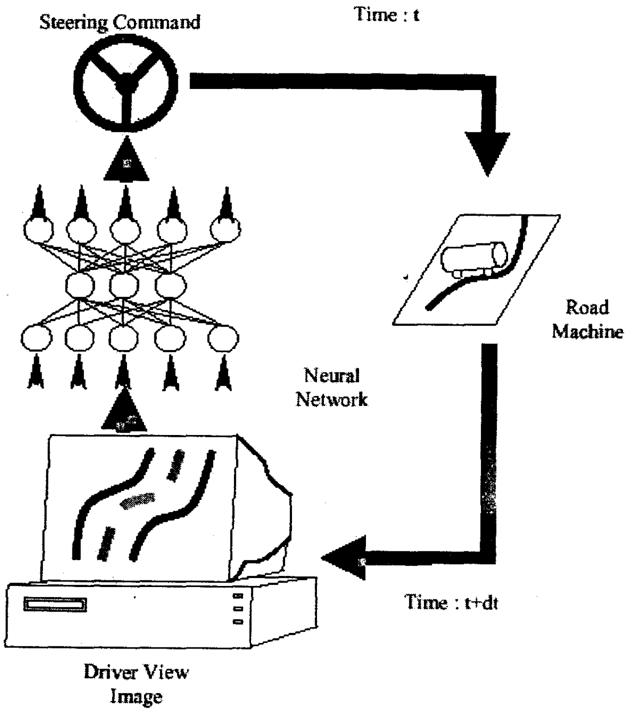


Fig. 11. Open-loop Controller Design

Some feed-forward elements can be introduced into the controller design by having the controller determine a trajectory of steering commands over the next n time steps and feeding back future values of that trajectory. The input to the controller is then the current image and a feedback of the anticipated steering commands for time steps 2 through n. This design depicted in Fig. 12 provides some memory of previous views and would smooth responses to image disturbances.

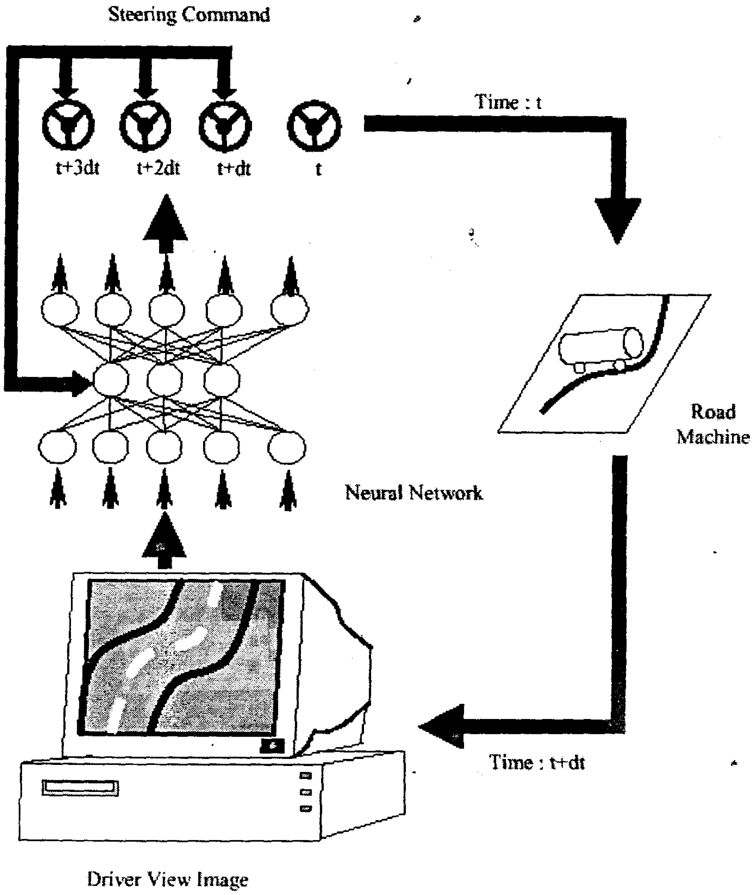


Fig. 12. Feedback Controller Design

8. CONCLUSION

We have discussed the major navigation systems by now. Today different navigation systems exist in the market. For example PHILIPS has come out with CARIN, which is a part of the new generation of GPS based in car navigation system. CASIO has come out with a GPS watch capable of locating your exact position and navigate to your destination. Within a short span of time these navigation systems will be introduced all over the world, which aids the human race for better navigation.