DEFINING THE “DIGITAL HIGHWAY”

THE UNIVERSITY OF NEVEADA, LAS VEGAS
HOWARD R. HUGHES COLLEGE OF ENGINEERING

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ABSTRACT

The United States Department of Transportation’s (DOT) mission is “ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future.” The DOT Strategic Plan states that new technologies must be developed to monitor highway and vehicle performance and provide information to improve highway and driver performance. This project supports the goals of the DOT by developing methods to define highway characteristics and monitor vehicle performance in real-time as well as displaying the information in the form of a “Digital Highway.”

The “Digital Highway” is a dynamic and real-time description of the physical and operational characteristics of our nation’s highways that positively affects the performance, efficiency, safety, security, and comfort of drivers. The “Digital Highway” is the backbone that supports the concept of the intelligent highway transportation system of the future. The information contained in the “Digital Highway” database can be used to support future research in a wide range of transportation areas. This project focuses on developing various parameters needed to define the “Digital Highway” on fourteen miles of highway in Nevada. A website has been developed to display static information including lane locations and exit ramps that were measured to an accuracy of ±152.4 millimeters (6 inches). Dynamic information including long-range weather forecasts and planned construction projects are accessible through the website. Real-time information from stationary cameras along the freeway and current accident reports can also be accessed. Real-time communication has been developed to transfer data from a test vehicle to track vehicle location and performance.
# SI Metric Conversion Chart

## Approximate Conversions to SI Units

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NOTE: Volumes greater than 1000 L shall be shown in m³

| **MASS** |
| oz      | ounces              | 28.35       | grams        | g      |
| lb      | pounds              | 0.454       | kilograms    | kg     |
| T       | short tons (2000 lb) | 0.907       | megagrams    | Mg (or "metric ton") |

**TEMPERATURE (exact degrees)**

| °F     | Fahrenheit     | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |

**ILLUMINATION**

| fc     | foot-candles   | 10.76       | lux      | lx |
| fl     | foot-Lamberts  | 3.426       | candela/m² | cd/m² |

**FORCE and PRESSURE or STRESS**

| lbf    | poundforce     | 4.45        | newtons   | N    |
| lbf/in²| poundforce per square inch | 6.89       | kilopascals | kPa  |
### APPROXIMATE CONVERSIONS FROM SI UNITS

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<th>Definition</th>
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<td>ABS</td>
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<td>Application Programming Interface</td>
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<td>CAP</td>
<td>Common Ahead Point</td>
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CHAPTER 1. INTRODUCTION

The research in this project was focused on defining a fourteen-mile section of urban highway in southwest Nevada as a Digital Highway and developing real-time communication and monitoring to track a vehicle on the highway. Static and dynamic information is displayed on an interactive web system that was developed for the project. A communication link between a test vehicle and the Digital Highway was developed to provide the ability to track and display the vehicle location on the highway in real-time.

A fourteen-mile section of Interstate 15 from the exit and entrance of Charleston Boulevard to the exit and entrance of St. Rose Parkway was selected for the Digital Highway because it represents typical urban freeway characteristics. Static, dynamic, and real-time parameters that are required to define the Digital Highway were identified. Static parameters such as lane locations and speed limits do not change with time. Dynamic parameters such as construction areas and long range weather forecasts change slowly but can have a significant impact on highway traffic flow and are used for transportation planning. Real-time parameters are an instantaneous snapshot of the actual conditions that exist on the highway such as the actual average speed at which vehicles are traveling.

Static Digital Highway information included on the Digital Highway web system includes key infrastructure such as entrance and exit ramps, cross streets, grade, speed limit, road warnings, and service areas. Methods to represent the static highway infrastructure and store it in the Digital Highway format were developed. Accurate locations for all driving lanes are required to support the requirements of the vehicle tracking system because the exact traffic lane in which a vehicle is driving must be discernable. The locations of highway driving lanes were measured with a Global Positioning System (GPS) mounted on a test vehicle with an accuracy of ±152.4 millimeters (6 inches). Curve fitting was then used to construct and display the lanes on the Digital Highway web system.

Dynamic Digital Highway information includes lane closures, construction areas, average traffic density, and long-range weather forecasts. Sources of dynamic highway information were identified. Methods to access the information and enter it into the Digital Highway database were developed. Users can display dynamic highway information on the Digital Highway Web System through a menu.

The real-time capability of the Digital Highway web system provides both vehicle tracking capability and access to The Freeway and Arterial System of Transportation (FAST). FAST is a department of the Regional Transportation Commission of Southern Nevada and provides video monitoring of sections of Interstate 15 through a series of cameras mounted along the highway. The vehicle tracking provides the capability to monitor a vehicle with an accuracy of ±152.4 millimeters (6 inches) which is sufficient to detect vehicle lane changes. Extremely high accuracy vehicle monitoring is required to support future applications such as driver performance monitoring and autonomous vehicle operation. A communication link was developed to transmit information from the test vehicle to the Digital Highway database.
The deliverables resulting from this research project are:

1. A database was developed to maintain the static, dynamic, and real-time parameters, which define the Digital Highway on fourteen miles of urban Las Vegas highway.
2. A web-based system was developed to allow researchers to access the Digital Highway database.
3. A demonstration featuring real-time communication of the position of a test vehicle with the Digital Highway web based system was developed.
4. A report describing the Digital Highway with detailed instructions for researchers who desire to access the database was constructed.

The Digital Highway is the next step in the development of the Intelligent Highway Transportation System of the future. It will be the central warehouse for static, dynamic, and real-time highway information. The Digital Highway is the means by which highway information will be collected, summarized and accessed in the future. The Digital Highway will be the nucleus that supports the development of analysis and management techniques required to efficiently plan and control highways. In rapidly expanding urban areas, the real-time information contained in the Digital Highway database will play an essential role in managing and controlling the traffic flow on highways with traffic densities near capacity and constantly changing highway conditions. It will support future development of autonomous vehicle operation. This project focused on developing methods to utilize vehicle and highway information to define the infrastructure and operation of our highways on a real-time basis.
CHAPTER 2. LITERATURE REVIEW

Much of the research relevant to the Digital Highway is related to the Intelligent Transportation System. Research associated with the Intelligent Transportation System includes autonomous vehicle systems, safety and effects, driver assistance programming, vehicle instrumentation, long-term consequences, as well as the benefits of the system as a whole. Websites and highway monitoring systems developed by other researchers and by state agencies that are related to the Digital Highway were reviewed also. These reviews provided a basis for the design and development of the Digital Highway website developed in this project. Published literature related to real-time performance and communication that was relevant to the Digital Highway was reviewed. Sources of research literature were webpage resources found through the University of Nevada, Las Vegas Library Articles and Databases and Google’s Scholar database. Literature that was significant to the Digital Highway project was summarized and included in the literature review.
LITERATURE RESEARCH

I-15 SOUTH PROJECT OF NEPA
Prepared By: Chequala Fuller

Summary:
- NEPA plans to expand 12 miles of the Interstate 15 corridor
- Working to expand the freeway lane usage and expect to increase traffic flow per day from 42,000 vehicles in 2003 to 156,000 by 2030
- Freeway expansions should help the flow of traffic become more sufficient and hassle free.
- Plans to expand the traffic lanes in Las Vegas Boulevard. Instead of being a six lane travel road NEPA looks to make it into a ten lane travel road
- Aim to make the flow on the strip become more pleasurable as well
- Proposed interchanges are going through the process of being analyzed but is also slowly commencing.

Abstract: Within the next 10 years, NEPA is planning to expand the lanes on the I-15 highway and Las Boulevard. Traffic congestion is worsening and they are trying to find solutions to resolve the issue.
(I-15 South NEPA; May 1, 2007; http://www.i15southnepa.com/)

TOWARD THE DESIGN OF INTELLIGENT TRAVELER INFORMATION SYSTEMS
Prepared By: Marcie Arai

Summary:
- Discusses concerns and the basic activities of a specific system called ATIS
- Covers approximate reasoning, machine learning, natural language processing, etc.

Abstract: The emergence of Intelligent Transportation Systems (ITS) has fostered the development of advanced traveler information systems (ATIS). These systems are designed to assist travelers in making pre-trip and enroute travel choice decisions. It is contended that while many traveler information systems are innovative and make use of cutting edge technologies, they lack real machine intelligence and therefore may be limited in their ability to service the traveling public over the long-run. The purpose of this paper is to present a vision of the next generation traveler information system, termed Intelligent Traveler Information Systems (ITIS) in which artificial intelligence techniques are drawn upon to create systems capable of providing travelers with more personalized planning assistance.

VISION-BASED INTELLIGENT VEHICLES: STATE OF THE ART PERSPECTIVES
Prepared By: Marcie Arai and Ann Marie Frappier
Summary:
- Explores “machine vision”; page 3 beings to talk about the sensors used
- Page 4 – extensive list of approaches to automatic road following and a table of pros and cons of the most typical assumptions in lane detection.
- Statistics and information is provided about “No Hands Across America”

Abstract: Recently, a large emphasis has been devoted to Automatic Vehicle Guidance since the automation of driving tasks carries a large number of benefits, such as the optimization of the use of transport infrastructures, the improvement of mobility, and the minimization of risks, travel time, and energy consumption. This paper surveys the most common approaches to the challenging task of Autonomous Road Following reviewing the most promising experimental solutions and prototypes developed worldwide using AI techniques to perceive the environmental situation by means of artificial vision.

The most interesting results and trends in this field as well as the perspectives on the evolution of intelligent vehicles in the next decades are also sketched out.


A SURVEY OF INTELLIGENT VEHICLE APPLICATIONS WORLDWIDE
Prepared By: Marcie Arai

Summary:
- Overview of the application of IV systems such as sensing and intelligent algorithms
- Systems that assists the driver in vehicle operations or fully controlling the vehicle.

Abstract: The field of intelligent vehicles is rapidly growing worldwide, both in the diversity of applications and in increasing interest in the automotive, truck, public transport, industrial, and military sectors. These systems offer the potential for significant enhancements in safety and operational efficiency. As one component of ITS, intelligent vehicle (IV) systems use sensing and intelligent algorithms to understand the environment immediately around the vehicle, either assisting the driver in vehicle operations (driver assistance) or fully controlling the vehicle (automation). Following the success of information-oriented systems, IV systems can be seen as the “next wave” for ITS, functioning at the control layer to enable the driver-vehicle subsystem to operate more effectively in the highway environment. This article provides a broad overview of applications and selected activities in this field


USABLE VEHICLE NAVIGATION SYSTEMS: ARE WE THERE YET?
Prepared by: Ann Marie Frappier

Summary:
- Overview of issues concerning the design of the Human-Machine Interface (HMI) for GPS-based vehicle navigation systems.
Abstract: GPS-based vehicle navigation systems are already available to drivers in many European countries, and these will soon be affordable by the mass market. This paper provides an overview of issues concerning the design of the Human-Machine Interface (HMI) for this technology. Research has contributed to the development of guidelines and best practice, which have shaped the design of current systems. In particular, studies have established and quantified the benefits of simple turn-by-turn guidance (symbols and voice) over the use of map-based formats. It is argued that improvements must be made to the HMI for this technology to ensure truly ‘usable’ systems. In particular, there is a need to include stronger visual cues (such as landmarks) within voice instructions, reform timing rules, universally adopt high display positions, and disable demanding functions when the vehicle is in motion. (Burnett, GE. "Usable Vehicle Navigation Systems: Are we there yet?" 2000. <http://www.cs.nott.ac.uk/~geb/VES2000-burnett.pdf>.)

PFC: A PACKET FORWARDING CONTROL SCHEME FOR VEHICLE HANDBOVER OVER THE ITS NETWORKS
Prepared by: Victor Wang

Summary:
- A vehicle that contains ITS is capable of connecting to the base station and other vehicles with the similar ITS.
- After the vehicle moves far away from the transmission range, the ITS of the vehicle will have to search for the other available source of connecters; such condition is referred as vehicle handover in this research report.
- Reduce the message transmission time during vehicle handover is an important issue for the networks of ITS.
- This research proposed a solution to solve this issue by a technique called Packet Forwarding Control (PFC) which is capable of selecting a common ahead point (CAP) as a tunnel source for the future transmission.
- During the vehicle handover, the data sent from the base station or other sources can be forward through CAP to a new access router (NAR) directly without having to travel from the previous access router (PAR) to NAR; in another words, PFC created a shortcut for the data transition.
- This solution was proved having shorter packet transmission time and short handover delay than the original condition.

Source Cited:
Chung, Ming Huang, Shu Chiang Meng, and Heng Hsu Tz. PFC: a Packet Forwarding Control Scheme for Vehicle Handover Over the ITS Networks. Tainan: Laboratory of Multimedia Mobile Networking, Department of Computer Science and Information Engineering, National Cheng Kung University, 23 Dec. 2007 <http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TYP-4RDS43D-3&_user=10&_coverDate=12%2F23%2F2007&_alid=736811053&_rdoc=1&_fmt=high&_orig=search&_cdi=5624&_sort=d&_docanchor=&view=c&_ct=1&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=9b53ed4a6b8a8287e40711d7e3b65bb>. 
RECURSIVE 3-D AND RELATIVE EGO-STATE RECOGNITION
Prepared By: Chequala Fuller

Summary:
- PDF article consists of very detailed information on the 3-D road project
- Includes calculations and road curvature diagrams
- General issue of recognizing both horizontal and vertical road curvatures while driving along the road has been solved
- Has been proven that 3-D scene recognition during motion is far accurate and easier than static cameras
- A European project, PROMETHEUS aims for this technology development to become utilized throughout their countries
- New technological innovation is extremely important because it is said to considerably help reduce the present death toll and economic losses in road traffic in the future.

Abstract: The general problem of recognizing both horizontal and vertical road curvature parameters while driving along the road has been solved recursively. A differential geometry representation decoupled for the two curvature components has been selected. Based on the planar solution of [71 and its refinements, a simple spatio-temporal model of the driving process allows us to take both spatial and temporal constraints into account effectively. The estimation process determines nine road and vehicle state parameters recursively at 25 Hz (40 ms) using four Intel 80286 and one 386 microprocessor. Results with the test vehicle (VaMoRs), which is a 5-ton van, are given for a hilly country road.
(Dickmanns, Ernst D., and Birger D. Mysliwetz. “Recursive 3-D Road and Relative Ego-State Recognition.” February 1992.)

REAL TIME VISION FOR INTELLIGENT VEHICLES
Prepared By: Marcie Arai

Summary:
- Stop-And-Go system which is an intelligent cruise control that autonomously follows a lead vehicle
- Built by DaimlerChrysler
- Detects stationary obstacles, recognizing the traffic signs and traffic lights that are relevant
- Detects and classifies additional traffic participants such as pedestrians
- Also talks about the computer hardware and computer software that the test vehicles are equipped with

Abstract: The authors first discuss the Intelligent StopandGo system, a sophisticated cruise control that autonomously follows a lead vehicle, pays attention to the relevant elements of the traffic infrastructure, and accounts for other traffic participants. The Intelligent StopandGo represents a multiyear effort by DaimlerChrysler to build a sophisticated cruise control that can
function on highways, on secondary roads, and in urban environments. It combines the following capabilities: extracting lane boundaries, even when they are not clearly marked and do not contain the typical structure of highways; detecting a vehicle that can be followed, estimating its distance, speed, and acceleration; detecting stationary obstacles, such as parked cars, which limit the available free space; recognizing the traffic signs and traffic lights that are relevant; and detecting and classifying additional traffic participants, such as pedestrians, who might cut in between the lead vehicle and the host vehicle. The DaimlerChrysler demonstrator Urban Traffic Assistant (UTA) has devoted special attention to information, warning, and assistant functions in an inner-city environment. UTA is an E-class Mercedes-Bent containing sensors for longitudinal speed, longitudinal and lateral acceleration, yaw and pitch rate, and the steering wheel angle. It is equipped with a stereo black-and-white camera system as well as a color camera. UTA has access to throttle, brake, and steering. Furthermore, it displays the results of the perceptual modules in a graphical environment from either the driver's perspective or a virtual viewpoint. The computer hardware in UTA comprises three 400-MHz Linux/Pentium II (SMP) PCs for the perception of the environment and one Lynx/604e PowerPC for the control of sensors and actuators (Gavrila, D. M., et al. "Real Time Vision for Intelligent Vehicles." Instrumentation and Measurement Magazine, IEEE 2001: 22-27.)

POTENTIAL SAFETY IMPACTS OF AUTOMOTIVE NAVIGATION SYSTEMS
Prepared by: Ann Marie Frappier

Summary:
- Navigation Systems- identifies potential topics of concern relating to the driver interface.
- Describes measures by which safety of navigation systems can be assessed.
- Description of likely crash scenarios.

Abstract: This paper does not purport that navigation systems are safe or unsafe, but attempts to identify potential topics of concern relating to the driver interface. The first section of the paper describes some of the classes of measures by which the safety of navigation systems can be assessed. Of them, eye fixation frequencies and duration, TTC, and TLC have the most promise for pinpointing safety concerns. However, additional work is needed to develop the tools to collect and analyze such measures. Of the navigation tasks that drivers can perform, the primary concern is with destination entry, though information retrieval, route following (with maps), and destination retrieval also deserve attention. A better understanding of the crash-inducing potential of navigation systems may be obtained by consideration of likely crash scenarios, some of which are described. Systematic analyses of crash scenarios involving navigation systems have yet to appear in the literature.

ROAD PROFILE RECOGNITION FOR AUTONOMOUS CAR NAVIGATION AND NAVSTAR GPS SUPPORT
Prepared By: Marcie Arai

Summary:
• ABS sensors used to detect driving direction
• Layout of the nav system is discussed
• Discusses simulation carried out over 150 km

Abstract: We discuss autonomous car navigation based on updating dead reckoning (DR) by road profile recognition (RPR). The navigation system requires sensors to detect changes in altitude and driving direction, which are installed in modern cars for different purposes (e.g. ABS sensors). The layout of the navigation system is discussed and simulations are carried out over driving distances of approximately 150 km on the basis of realistic road data and ordinary sensor accuracies. Positioning errors of lower than 10 m (standard deviation) are observed. To achieve this accuracy the synchronization error between measured and mapped data must be continually estimated. The introduced navigation method is ideal to complete present commercial car navigation systems using Navstar GPS.


INTELLIGENT AND INTEGRATED DRIVER ASSISTANCE
Prepared by: Chequala Fuller

Summary:
• Book written on Advanced Driver Assistance Systems (ADAS)
• Supports drivers’ decision making
• Talks about ADAS and how it contributes to increase of safety and comfort
• Ergonomically based and has useful sources for camera, vehicle and road sensors, which is relevant to the UTC project and can be very resourceful.

Abstract: Swerving out of the lines while driving will soon be solved. The Intelligent and Integrated Driver Assistance System is creating a sensor device enabled to control car performance. This new technology is being created to help keep drivers safe on the road, aiming to make a decrease in vehicle collisions.


TOWARDS AUTONOMOUS VEHICLES FOR FUTURE VEHICLES FOR FUTURE
INTELLIGENT TRANSPORTATION SYSTEMS
Prepared By: Marcie Arai

Summary:
• Gives equations and describes the system that allows an autonomous vehicle to change lanes, maneuver around obstructions, parallel park, etc.
• Describes steps that vehicle takes to analyze a situation and how it responds

Abstract: Developing new Intelligent Transportation Systems which take into consideration the socio-economical, environmental, and safety factors of the modern society, is one of the grand challenges of the next century. Recent progress in the ends of Mobile Robots, Control
Architectures, and Computer Vision allows us to now envisage the integration of new autonomous and driving-assistance capabilities within future vehicles. This paper presents the concept of "Automated Urban Vehicle" which is currently developed within the scope of the French "Praxiteles" and "Automated Road" programmes. It focuses onto the novel Control and Decisional Architecture, which has been developed for providing each vehicle with the required autonomous capabilities. Experimental results obtained with our automatic electric vehicles are presented for three types of maneuvers: lane following/changing, parallel parking, and platooning.


CAPC ROAD—WARNING PROTOTYPED
Prepared By: Chequala Fuller

Summary:
- Article is a detailed design presentation of the CAPC prototype vehicle
- Includes detailed descriptions on the software and hardware used for this experiment
- A 1995 Ford Taurus SHO is used for experimental purposes
- Project is aimed towards solving issues of roadway drifting at shallow angles due to inattention, intoxication, fatigue, and other causes
- CAPC, Crewman’s Associate for Path Control, is an automatic road-departure warning system invented for motor vehicle drivers
- A sense of transducers and Camera sensors are used to detect unintended road departures and send out a warning to the driver

Abstract: The Crewman’s Associate for Path Control (CAPC) is an automatic road-departure warning system for motor vehicle drivers. This article presents the design of, and preliminary field results from, the CAPC prototype vehicle, a modified 1995 Ford Taurus SHO. The CAPC system is intended for highway drivers who are drifting off the roadway at a shallow angle of departure due to inattention, drowsiness, intoxication, or other causes. A camera senses the roadway ahead, and a suite of transducers provide measurements of vehicle motion and driver steering commands. These are used to anticipate unintended road departures and warn the driver. Warning and intervention functions for CAPC have been developed during ongoing research at the University of Michigan; the algorithms are reviewed here in the context of the prototype. The prototype hardware and software are described in detail, and preliminary experimental data from the field is presented.


INTELLIGENT TRANSPORTATION SYSTEMS—TRAVELERS’ INFORMATION SYSTEMS: THE CASE OF A MEDIUM SIZE CITY
Prepared By: Marcie Arai

Summary:
- Outlines a GPS/GPRS based buses’ location system in Heraklion, Crete
- Tracks buses throughout the city to improve efficiency and customer satisfaction
Abstract: Intelligent transportation systems and associated travelers' information systems can dramatically influence the way people decide to travel, thus the way of living in urban areas. In this paper a bus arrival time prediction and the associated travelers' information system of a medium size city is presented. The system uses the latest GPS technology for automatic bus location and GPRS technology for communications. The real time availability of all buses' exact locations and speeds enables the system to have very clear traffic information of the city's main streets and to predict arrival times with satisfactory accuracy. Some financial aspects of the project are discussed as well.

(Manolis, Kavoussanos, and Daskalakis Kwstis. "Intelligent Transportation Systems - Travelers' Information Systems: The Case of a Medium Size City." June 3-5, 2004.)

SPECTRAL BASIS NEURAL NETWORKS FOR REAL-TIME TRAVEL TIME FORECASTING
Prepared by: Ann Marie Frappier

Summary:

- Examines how real-time information gathered as part of intelligent systems can be used to predict link travel times for one through five times duration.
- forecasting
- intelligent transportation systems
- neural networks
- real-time programming
- spectral analysis
- travel time

Abstract: This paper examines how real-time information gathered as part of intelligent transportation systems can be used to predict link travel times for one through five time periods ahead (of 5-min duration). The study employed a spectral basis artificial neural network (SNN) that utilizes a sinusoidal transformation technique to increase the linear reparability of the input features. Link travel times from Houston that had been collected as part of the automatic vehicle identification system of the TransStar system were used as a test bed. It was found that the SNN outperformed a conventional artificial neural network and gave similar results to that of modular neural networks. However, the SNN requires significantly less effort on the part of the modeler than modular neural networks. The results of the best SNN were compared with conventional link travel time prediction techniques including a Kalman filtering model, exponential smoothing model, historical profile, and real-time profile. It was found that the SNN gave the best overall results.


ITS DECISION—SERVICES AND TECHNOLOGIES
Prepared By: Marcie Arai

Summary:
- Provides list of traffic control terminology
- Offline signal timing optimization models
- Adaptive control strategies
- Case studies presenting data of implementation

**Abstract:** As population continues to grow, the demand on our existing transportation system will become increasingly hard to meet. Roads and highways are unlikely to expand much due to cost and dwindling land supply, so intelligent systems such as advanced traffic signal control will be critical to operating our current roadway systems at maximum capacity. Furthermore, poorly timed signals can waste time, fuel, and money. In a street network with poorly timed traffic signals, the fuel consumed by vehicles stopping and idling accounts for approximately 40% of network wide vehicular fuel consumption [8].

Traffic signal improvements generally provide the greatest payoff for reducing surface street congestion when compared with other methods, such as widening roads [12]. Advanced traffic signal control can help ease congestion and its negative externalities without the cost and environmental impact of road expansion. (Pearson, Rebecca. "ITS Decision - Services and Technologies." Nov 1, 2001.<http://www.calccit.org/itsdecision/serv_and_tech/Traffic_signal_control/trafficsig_report.html>).

**SURFACE TRANSPORTATION WEATHER APPLICATIONS**

Prepared by: Ann Marie Frappier

**Summary:**
- Response to weather threats employed through three types of mitigation measures- control, treatment, and advisory strategies.
- Better road management strategies- road weather data sharing, analysis, and integration.
- Environmental Info. Supports- traffic, maintenance, and emergency managers, allows motorists to cope with weather effects through trip deferrals, route detours, or driving behavior.
- The Road Weather Management Program of the Federal Highway Administration promotes and facilitates deployment of integrated road weather systems, decision support applications, and effective management practices.

**Abstract:** Weather threatens surface transportation nationwide and affects roadway mobility, safety, and productivity. There is a perception that traffic managers can do little about weather. However, three types of mitigation measures—control, treatment, and advisory strategies—may be employed in response to weather threats. Road weather data sharing, analysis, and integration are critical to the development of better road weather management strategies. Environmental information serves as decision support to traffic, maintenance, and emergency managers; and allows motorists to cope with weather effects through trip deferrals, route detours, or driving behavior. The Road Weather Management Program of the Federal Highway Administration (FHWA) promotes and facilitates deployment of integrated road weather systems, decision support applications, and effective management practices.

(Pisano, Paul; and Lynette C. Goodwin. "Surface Transportation Weather Applications."
PROGRAMMER API’S—DISTANCE AND RADIUS
Prepared By: Marcie Arai

Summary:
- Program returns north, south, east, and west boundaries of the radius of a ZIP Code
- Find distance between two ZIP Codes
- Can use ZIP database to match all the ZIP Codes in the area found by this program

Abstract: A product meant to be used by web programmers, which will help solve the problem of dealing with converting latitude and longitude to a ZIP Code. This is something to look into in the future when addressing an issue broader than our 10 miles of highway. We will be able to pass the program a latitude/longitude, and a specified radius and it will return the lat/lon coordinates for the north, south, east, and west boundaries of the radius we entered. We can then find all ZIP Codes in our data that have lat/lon coordinates that fall within those boundaries. ("Programmer APIs - Distance and Radius Package." 2008. <http://www.zipcodedownload.com/Products/Product/DistRadAPI/Standard/Overview/>)

A LANE TRACKING SYSTEM FOR INTELLIGENT VEHICLE APPLICATIONS
Prepared By: Marcie Arai

Summary:
- Describes an image-based lane tracking system
- Details the steps of the algorithm and how it determines road geometry and other relevant factors

Abstract: An image-based lane tracking system for use in intelligent vehicles is developed. For each frame, the algorithm develops estimates of the geometry and width of the current lane ahead of the vehicle and the position and orientation of the vehicle with respect to the center-line of the lane. Basic image processing techniques are used to extract a candidate set of lane marker locations from the image. These are used to generate a pool of center-line candidates with properties dependent on the lane markers. A method of elimination based on dynamic programming is used to isolate a final set of center-line candidates that constitute the actual geometry of the road. The road geometry is modeled using a clothoid curve, which stipulates that the curvature of the road vary as a linear function of arc length. The clothoid center-line representation also aids in determining the offset of the vehicle from the center-line and the heading angle of the vehicle with respect to the road. Finally, a Kalman filter is applied to the estimated parameters to preserve smoothness and to predict lane parameters for the next image frame. A set of confidence measures for the estimated data is calculated for use by a higher level data fusion algorithm the system gives an estimate of parameters under normal traffic and driving conditions and runs in real-time on off-the-shelf hardware. (Redmill, K. A., et al. "A Lane Tracking System for Intelligent Vehicle Applications." Intelligent Transportation Systems, 2001. Proceedings. 2001 IEEE. Oakland, CA, Aug 25-29.)
COMPARISON OF LOW-FIDELITY TRANSIMS AND HIGH-FIDELITY CORSIM HIGHWAY SIMULATION MODELS W/ INTELLIGENT TRANSPORTATION SYSTEMS DATA
Prepared by: Ann Marie Frappier

Summary:
- Transportation planners’ use of: the compare of low-fidelity TRANSIMS and High-fidelity CORSIM with supporting evidence test trials done on roads.

Abstract: In recent years, there has been increased emphasis in the transportation modeling field on replacing macroscopic supply functions with simulation models. For example, the highway supply relationship in the Transportation Analysis and Simulation System (TRANSIMS) is based on a low-fidelity micro simulation model. How the TRANSIMS low-fidelity highway simulation module compares with a high-fidelity model and with empirical observations from intelligent transportation system (ITS) implementation projects has been examined. A section of Interstate 10 in Houston, Texas, was used as a test bed and ITS data were obtained for calibration and validation purposes. For comparison, the high-fidelity CORSIM model, which is used extensively in North America for operational analyses, was calibrated and tested with the same data. The two models did equally well at replicating the baseline volume data. In addition, the mean travel time output from the calibrated TRANSIMS model tended to be about 20 percent greater than the mean travel time from the calibrated CORSIM model. In general, the observed travel times were found to lie between the simulated values from the TRANSIMS and CORSIM models. More important, the link and corridor travel time variability appeared to be significantly less than the observed travel time variability. It is hypothesized that this difference may affect certain measures of effectiveness, such as automobile emissions, that will be used by transportation planners.


ITS INTEGRATION HOMEPAGE
Prepared By: Marcie Arai

Summary:
- Equipment interoperability (e.g. ambulances communication with traffic signals)
- Outlines freeway management systems
- Surveillance (ramp closures)
- Information dissemination (dynamic message signs)
- Road geometry warning systems (intrusion protection)

Abstract: This website provides an overview of the applications addressed by the Federal Intelligent Transportation Systems (ITS) program and contains links to various information resources that will be useful in the planning and deployment of ITS. Click on an icon below to get more information about an ITS application area.


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RITA UTC THEMES AND CONTACT INFORMATION
Prepared By: Marcie Arai

Summary:
- UTC Themes
- UTC Names and contact info

Abstract: Lists all University Transportation Systems throughout the nation for FY 05 – FY 09 and the themes they are pursuing. In addition, lists contact information of the directors of each UTC.
("RITA UTC Themes and Contact Information." <http://utc.dot.gov/utc_themes.html>.)

ROAD WARRIOR Q&A: NEW INTERCHANGE FEW YEARS DOWN ROAD
Prepared By: Chequala Fuller

Summary:
- Base on the issue concerning the freeway interchanges located towards the southern end of I-15
- Interchanges have been mainly around the area south of Blue Diamond Road which has caused several problems for local residents
- Locals have become frustrated with the misleading traffic message boards around the interchange areas
- Demanded reasonable answers as to why NDOT and LVACTS have been slacking on traffic sign updates
- Had been issues with south I-15 and U.S highway 95 due to the lack of approval from the Federal Highway Administration and NDOT
- Issue had caused the effects of traffic misunderstandings and angered residents.

Abstract: NDOT is working to expand the roads to prevent traffic jams and congested roads. On Las Vegas Boulevard NDOT is designing to expand a four lane road into a six lane road. On the I-15 highway, they are planning to expand the four-five lane highways into a ten lane highway.
(Squires, Micheal. "Road Warrior Q&A: New Interchange Few Years Down Road." (2007).

TELETYPE PRODUCTS—US SOFTWARE
Prepared By: Marcie Arai

Summary:
- Weather map software
- Compatible with laptops and most GPS receivers

Abstract:
The site where you can see the software that is needed to run Teleteype’s weather map. It can be downloaded directly to a laptop but requires us to have our own GPS receiver or one of the Teleteype GPS receivers.
INTELLIGENT NAVIGATION OF AUTONOMOUS VEHICLES IN AUTOMATED HIGHWAY SYSTEMS: LEARNING METHODS AND INTERACTING VEHICLES APPROACH
Prepared by: Ann Marie Frappier

Summary:
- Artificial Intelligence technique called stochastic learning automata to design an intelligent vehicle path controller-proposition.

Abstract: One of today's most serious social, economical and environmental problems is traffic congestion. In addition to the financial cost of the problem, the number of traffic related injuries and casualties are very high. A recently considered approach to increase safety while reducing congestion and improving driving conditions is Automated Highway Systems (AHS). The AHS will evolve from the present highway system to an intelligent vehicle/highway system that will incorporate communication, vehicle control and traffic management techniques to provide safe, fast and more efficient surface transportation. A key factor in AHS deployment is intelligent vehicle control. While the technology to safely maneuver the vehicles exists, the problem of making intelligent decisions to improve a single vehicle's travel time and safety while optimizing the overall traffic flow is still a stumbling block.

We propose an artificial intelligence technique called stochastic learning automata to design an intelligent vehicle path controller. Using the information obtained by on-board sensors and local communication modules, two automata are capable of learning the best possible (lateral and longitudinal) actions to avoid collisions. This learning method is capable of adapting to the automata environment resulting from unmodeled physical environment. Simulations for simultaneous lateral and longitudinal control of an autonomous vehicle provide encouraging results. Although the learning approach taken is capable of providing a safe decision, optimization of the overall traffic flow is also possible by studying the interaction of the vehicles.

The design of the adaptive vehicle path planner based on local information is then carried onto the interaction of multiple intelligent vehicles. By analyzing the situations consisting of conflicting desired vehicle paths, we extend our design by additional decision structures. The analysis of the situations and the design of the additional structures are made possible by the study of the interacting reward-penalty mechanisms in individual vehicles. The definition of the physical environment of a vehicle as a series of discrete state transitions associated with a "stationary automata environment" is the key to this analysis and to the design of the intelligent vehicle path controller.


INTELLIGENT VEHICLE HIGHWAY SYSTEM MULTI-LANE SENSOR AND METHOD
Prepared By: Marcie Arai
Summary:
- Provides the full text of a patent issued for the item described in the title
- “A vehicle sensor providing the presence of a vehicle in a traffic lane and indicating the vehicle speed as it passed the sensor is disclosed in the above referenced application Ser. No. 07/980,273 issuing as U.S. Pat. No. 5,321,490.”
- The rest of the patent article is technical in detail and a sufficient vocabulary is needed to understand what it says about the processes of function and design.

Abstract: An Intelligent Vehicle Highway System (IVHS) sensor provides accurate information on real-time traffic conditions that can be used for incident detection, motorist advisories, and traffic management via signals, ramp meters, and the like. A diode-laser-based Vehicle Detector And Classifier (VDAC) measures the presence, speed, and three-dimensional profiles of vehicles passing beneath it within its multi-lane field-of-view coverage. The sensor uses pulsed laser range imaging technology adapted for determining the three-dimensional profile of the vehicle. The VDAC employs a rotating polygon mirror to scan a pulsed laser rangefinder across three lanes of a highway in order to measure the presence, speed, and height profiles of vehicles in all three lanes simultaneously. A receiver accepts reflections from beams transmitted from the sensor and provides inputs for determining time of flight, and a time interval between interceptions of the two divergent beams for the vehicle. An encoder tracks the position of the mirror for providing angle data with associated range measurements. The VDAC high signal-to-noise ratio and good spatial resolution result in highly accurate traffic-parameter measurements.


CARS SOON MAY ‘TALK’ TO ROADS, EACH OTHER
Prepared By: Marcie Arai

Summary:
- ITS technologies already developed by major companies
- Trouble-shooting efforts of Motorola and BMW North America

Abstract: Briefly lists various technologies for communicating cars that have already been developed including such things like following car alerted, computer takes control, or Intersection recognition radar. Also describes the efforts by companies such as Motorola and BMW North America to work out “thorny issues” in the programs path: compatibility, privacy, and control.

(Woodyard, Chris. "Cars Soon may 'Talk' to Roads, each Other." USA Today2005, sec. Technology:..)

DESIGN AND DEVELOPMENT OF FARM VEHICLE MONITORING AND INTELLIGENT DISPATCHING SYSTEM
Prepared By: Marcie Arai

Summary:
- Discusses a system designed to track farm vehicles over a large area of land
- Plots the most efficient rout for the driver to follow to his destination
- Outlines system structure, communication, hardware, etc.

**Abstract:** More and more large farms adopt precision agriculture technology in China. On the base of requirement investigation, the paper designed and developed Farm Vehicle Monitoring and Intelligent Dispatching System (FVMIDS) for a large farm, which owns 13,000 brm' of land and has the most advanced agricultural mechanism in the world. The principle, technology and method of GPS, GIS, GSM and operational research were used for system design and development. The system could meet the following requirement: vehicle dispatching, vehicle inducing, vehicle monitoring, farming operation analyzing & statistics, means of production dispatching, and so on. The model of vehicle dispatching based on "transportation problem" was emphasized in the paper. Test run shows that the system can meet all the requirements of the farm and decrease vehicle dispatching cost largely.

CHAPTER 3. DESIGNING THE “DIGITAL HIGHWAY”

The proposed research was focused on defining fourteen miles of Nevada highway on the Interstate 15 from Charleston Boulevard to St. Rose Parkway as a Digital Highway, designing a website to display the information and support a vehicle monitoring system. The static and dynamic parameters that describe the section of highway were measured and defined. Coordinates of the parameters were measured with a GPS mounted on a test vehicle with an accuracy of ±152.4 millimeters (6 inches). GPS coordinates for each freeway lane were measured and recorded in Degrees, Minutes, Seconds (DDMMSS) and converted to feet. A MATLAB program was written to construct the Digital Highway map from the GPS information (explained in CHAPTER 6). Discontinuities resulting from lost GPS signal when driving under overpasses were removed.

The “Digital Highway” was developed using MATLAB coding. The freeway edges are marked in blue; the individual lanes were marked in dotted red lines. This format was used for the section of the “Digital Highway” from St. Rose Parkway to Charleston Boulevard and from Charleston Boulevard to St. Rose Parkway. There was a provision to view the entire “Digital Highway” at one stretch or to view any of the zoomed sections of the fourteen-mile “Digital Highway”. The programming codes used as a part of designing the “Digital Highway” can be found in APPENDIX IV.

A method was developed to calculate the location of the lanes of a highway and display the image of the highway with an accuracy of ±152.4 mm (6 inches). A method had to be developed to track a vehicle in real-time and depict its image on the highway. To provide the needed accuracy it is required to take GPS coordinates every 38.125 m (125 ft). There is no actual way of knowing while driving if the vehicle has traveled 38.125 m (125 ft). While in motion any object, the test vehicle in this case, travels at a certain rate and is in motion for a certain period; consequently, its distance can be solved using the equation . Therefore, to design the “Digital Highway”, the time the truck was on the road was measured and used to calculate the distance traveled. A program called LabVIEW, which was on one of the onboard computers in the test vehicle, recorded the GPS locations that the truck has traveled. All of these coordinates or locations have been noted in notepad form recorded into a file on the Desktop labeled specifically for that purpose.

Once one trip on the “Digital Highway” was concluded a scripting language called Perl ran a GPS fix, which takes all of the values just gathered through LabVIEW and converts it into a different format for viewing. This format includes an unformatted time stamp, a time since start column, the latitude GPS coordinate in Degrees Minutes and Seconds, the latitude GPS coordinate in Decimal Degrees, these two columns once again, pertaining this time to Longitude. The method that was devised to draw the “Digital Highway” required two people. One person in the front passenger seat, with a stopwatch, pen, and paper. Another person in the back of the vehicle with the GPS and the laptop computer. At the beginning of the trip after entering the on ramp and right at the start of the drive both the person in front and in back start their equipment at approximately the same time. While the person in front starts the stopwatch and takes down
time split readings every time an exit sign is passed and notes the time on the sheet of paper, the person in the back has turned on, at the same moment, the LabVIEW program and is monitoring the GPS.

At the completion of the data collection cycle, the LabVIEW program in conjunction with Perl displays a time since start and the GPS coordinates. An Excel spreadsheet was used to collect the information including the exit column. Along with the exit column, are columns for rates, wherein possible rates are noted starting with fifty miles per hour and leading all the way up to seventy miles per hour. In between each rate is a column where the calculation $d = r \times t$ has been embedded, examples of which are depicted in Figure 2.4 and Figure 2.5. Therefore, for all of the intersections are known for any rate the truck might have been going, where it might be based also upon the time that was noted, during the drive in the truck, at that particular exit sign. Knowing now, the distance at every exit sign, one could go back to the converted sheet obtained through Perl and begin gathering coordinates every 38.125 m (125 ft). As mentioned before, feet is not depicted in this way, so one must again turn to the equation $d = r \times t$ and plug in this time 38.125 m (125 ft) for $d$ and the differing rates that could be traveled for $r$ making sure units are correct and solve for a time $t$ which is 1.3 seconds. Therefore, going back to the sheets gathered from Perl the values every 1.3 seconds are the only ones needed to depict the “Digital Highway”, whose process of obtaining those specific values are explained further and in detail the further on.

![Figure 3.1: GPS coordinates from Charleston Boulevard to St. Rose Parkway](image-url)
In summation the calculations to display The “Digital Highway” are centered on multiple equations narrowing to the information that 38.125 m (125 ft) / 1.3 seconds are the feet and time needed for there to be accurate distance between GPS locations. As well, that exits and locations are determined by the vehicle’s rate (the truck) and time, calculated in Microsoft Excel, in spreadsheet form, readily and easily.

REFORMATTING GPS DATA

During the process of creating and defining the “Digital Highway”, multiple acts of reformatting were performed through Microsoft Excel (further illustrations not mentioned below can be found in APPENDIX II). Several reformatted GPS data tables were constructed as a demand for sufficient organization and visual coherence in assisting in creating the mapping portion of the “Digital Highway”.

The mapping portion of the “Digital Highway” was the most challenging aspect demanded by this project. In order to commence an accurate mapping of the fourteen-mile span of highway the test vehicle has taken a vital role in accomplishing this task. Throughout the project, the test vehicle was used to gather all the GPS coordinates required to make the accuracy of the mapping possible. While driving the truck the GPS readings were automatically saved into LabVIEW and from there used to construe the readings from LabVIEW, place the GPS readings into Notepad and then convert the Notepad file into an excel sheet. It took several lengthy trips of driving the test truck along the left and right hand margins of each lane to obtain the exact GPS coordinates needed to further continue with this portion of the project. During these trips, the time it took to reach each exit was recorded for future use in the reformatting process. After gathering the needed GPS coordinates pertaining to each lane on each side of the fourteen-mile highway span, the converted the coordinates were entered into Excel using Perl. The converted

![Figure 3.2: GPS coordinates from St. Rose Parkway to Charleston Boulevard](https://example.com/gps_coordinates.png)
data in excel was used to identify increments of 1.3 seconds unused data was deleted to compress the massive amount of GPS data collected on one trip (Refer to Calculations). Fulfilling the compression of data required that every multiple of 1.3, beginning at zero, and continuing until the end of the data stream be collected. As soon as all the necessary data was highlighted and saved it was then recopied into another excel sheet and un-highlighted an example of which is captured in Figure 2.6. After the completion of compressing the converted data it was reformatted and each individual set of data was stored in tables.

Upon reformatting the data into excel, the times taken at each exit was used to match the location of those exits to its corresponding latitude and longitude. This time, latitude as well as longitude was depicted in a specific formatted table. This formatted table consists of six columns, which are labeled as Time since Start, Location, Latitude (degrees, minutes and seconds), Latitude (decimal degrees), Longitude (degrees, minutes and seconds) and Longitude (decimal degrees). Under each column, the converted data was copied and pasted under its specific heading, to which it applied an example of which is depicted in Figure 2.7.

Figure 3.3: L1 R7 raw GPS coordinate data
Figure 3.4: L1 R7 reformatted data tables
CHAPTER 4. THE DIGITAL HIGHWAY WEBSITE

The Digital Highway Website was designed to be an interactive system that provides users with easy access to the static, dynamic, and real-time information that defines the “Digital Highway”. It is a menu driven system which uses sophisticated algorithms and specialized software to access and display the defining parameters of the “Digital Highway”. Computer screens where designed to clearly display specific information and highway conditions. Website was designed to give users the option to zoom in on specific highway locations or obtain a broad view of an entire section of the highway. All of the web pages that have been developed for the Digital Highway Website are shown in APPENDIX III.

DREAMWEAVER

Adobe Dreamweaver is a web development application owned by Adobe Systems. Dreamweaver is available for Mac as well as Windows operating systems. Recent versions have incorporated support for web technologies such as Cascading Style Sheets (CSS), JavaScript and various server-side scripting languages and frameworks including ASP.NET, Cold Fusion, Java Server Pages and PHP.

Dreamweaver can hide the HTML code details of a page from the user, making it possible for non-coders to create web pages and sites. Dreamweaver can use "Extensions," small programs, which any web developer can write (usually in HTML and JavaScript). Extensions provide added functionality to the software for any individual who wants to download and install them. In addition, Dreamweaver also allows users to preview websites in many browsers, if they are installed on their computer. It as well has site management tools, such as the ability to find and replace lines of text or code by specific parameters specified across the entire site, and a “template” feature for creating multiple pages with similar structures.

In this project all the static and dynamic web pages were created using Dreamweaver (all web pages are fully depicted in APPENDIX III). The static web pages are those showing the speed limit maps (as referred to in Figure 4.1 and Figure 4.2) and general information about the Digital Highway project. Dreamweaver was essential to create and display the dynamic web pages such as those that consist of maps that report recent accident data, for the reason that the maps needed to be updated continuously in real-time (dynamically) over the internet. This feature is shown more realistically in Figure 4.3 and Figure 4.4. Furthermore, there are Flash applications (more information in Flash section, refer below) incorporated into the website, which are supported by Dreamweaver. Therefore, not all these specific tasks mentioned could have been accomplished without the incorporation and use of Dreamweaver.
Figure 4.1: Screenshot of I-15 speed limits.

Figure 4.2: Screenshot of Nevada speed limits.
Figure 4.3: Hybrid screenshot of Construction.

Figure 4.4: Map screenshot of construction around the county.
Adobe Flash is a multimedia platform created by Macromedia and currently developed and distributed by Adobe Systems. It has become a popular method for adding animation and interactivity to web pages. Flash is most commonly used to create animation and various web page components, for instance, to integrate video into web pages, as well as more recently, to develop rich Internet applications.

Flash supports bi-directional streaming of audio and video. It contains a scripting language called Action Script. Several software products, systems and devices are able to create or display Flash content, including Adobe Flash Player, which is available for most common web browsers, some mobile phones and other electronic devices. The Adobe Flash Professional multimedia authoring program is used to create content for the Adobe Engagement Platform, such as web applications, games and movies and content for mobile phones and other embedded devices.

Files in the SWF format, traditionally called "Shock Wave Flash" movies, "Flash movies" or "Flash games," usually have a .swf file extension and may be an object of a web page, strictly "played" in a standalone Flash Player, or incorporated into a Projector, a self-executing Flash movie (with the .exe extension in Microsoft Windows).

In the Digital Highway website, Flash is used for the home page animation shown in Figure 4.5, project demonstration and the Flash Player itself is used for the maps, so that they may be updated continuously in real-time (dynamically) and therefore, as consequence displayed on the website to view as displayed in Figure 4.6.

Figure 4.5: Screenshot of the “Digital Highway” Home Page.
ADOBE PHOTOSHOP

Adobe Photoshop, or more commonly referred to as Photoshop, is a graphic editing program developed and published, as well, by Adobe Systems. It is the current and primary market leader for commercial bitmap and image manipulation and is the flagship product of Adobe Systems. Photoshop CS3 features additions such as the ability to apply non-destructive filters, as well as new selection tools named Quick Selection and Refine Edge that make selection more streamlined. Add-on programs, such as Photoshop plug-in, which has the ability to act like mini-editors that can modify an image, can extend Photoshop functionality.

In this project, Adobe Photoshop was used to create various images and icons. These images were then used to represent several features within the website. The specific images that were created using Photoshop include, map pointers, video camera icons as captured in Figure 4.7 and Figure 4.8, accident symbols, etc.

Figure 4.6: Screenshot of live RTC video feed.
Figure 4.7: Screenshot of FAST video mapping across the I-15

Figure 4.8: Screenshot of FAST videos in Las Vegas
CHAPTER 5. THE TEST VEHICLE

A test vehicle shown in Figure 5.1 which is owned by the UNLV College of Engineering was used extensively in this project. Performance characteristics and the position of the vehicle can be measured with a variety of instrumentation which is permanently mounted on the bed of the truck. Two onboard computers are used to acquire and store information from the instrumentation. Figure 5.2 shows the instrumentation control cluster and computer layout in the rear seats of the vehicle. The test vehicle was used to measure the position of static highway information including the location of freeway lanes. A method to acquire information from the vehicle instrumentation and send and receive the information at a remote site in real-time was developed as part of the Digital Highway project.

Figure 5.1: The “Digital Highway” Test Vehicle

Figure 5.2: Test Vehicle instrumentation

The available instrumentations within the Test Vehicle are listed below and illustrated in Figure 5.3:

- AgGPS – Agricultural GPS, 10 Hz O/P rate:
- D link Fast Ethernet Cameras (5):
- IR temperature sensor - 22° F – 1832° F.
- Eaton Vorad Collision warning system (2).
- Raven-E EV-DO Modems (2).
- Linksys Ethernet cable/DSL Firewall Router with 4-port switch/VPN end port (2).
- Digital Geiger Counter – for Radiation Monitoring.
- Two HP laptops, with 512 MB RAM each and hard disk capacity of 60 GB each

![Data Flow Diagram](image)

**Figure 5.3:** A data flow set-up of the Test Vehicle instrumentation

**TEST VEHICLE EQUIPMENT**

**AgGPS (Agricultural GPS receiver)**

The GPS is the heart of the “Digital Highway” project as it used for both designing the Digital and for tracking the Test Vehicle on a real time basis. The GPS gives readings at an accuracy of + or – 152.4 mm (6 inches). The GPS can be configured for the type of output required. For this project, the GPS was configured to give 10 coordinate readings for every 0.1 seconds. The readings were obtained in the DDMMSS (Degrees, Minutes and Seconds) format, which were later converted in terms of distance (feet).

The GPS at its present capacity would not acquire any signal while under an overpass and takes approximately 6-7 seconds to regain its full signal strength once out of an overpass. The GPS values are recorded on the vehicle laptop computer using LabVIEW software. The operation of the GPS can be controlled using the application designed with the use of the LabVIEW software.
It is to be noted that the GPS can function optimally only when the signal is high, normally 10-11 units. When under any overhead obstacles the GPS fails to record any coordinate values. The receiver antenna for the GPS was mounted on top of the Test Vehicle. The GPS values acquired and stored in the laptop computer can be transmitted on a real-time basis from the Test Vehicle. The method and purpose of doing this will be seen in the later sections of this report.

The AgGPS accurately records GPS readings as the Test Vehicle moves along the highway lanes. The AgGPS 332 receiver combines high-performance GPS reception with a DGPS-capable receiver in a lightweight, durable housing. Some of the features of AgGPS 332 receiver are:

- 10 Hz (10 positions per second) output rate.
- 12 GPS tracking channels, code carrier channels.
- LED display.
- WAAS differential connection.
- Two ports that support both CAN 2.0B and RS-232.

The AgGPS receiver outputs positions in Degrees, Minutes, and Decimal Minutes (DDD°MM.m’). This is the NMEA standard format and is commonly used worldwide for data transfer between electronic equipment [3].

![The AgGPS Global Positioning System](image)

**Figure 5.4:** The AgGPS Global Positioning System

**Raven-E EV-DO Modems**

In addition to the AgGPS, the Raven EV-DO modem was an essential instrumentation to the project. The EV-DO modem allowed easy Internet access with the laptop computers in the Test Vehicle. Internet access was needed to transfer data from the source computer located in the vehicle to a destination computer in a remote location.

The EV-DO (Evolution Data Optimized) modem provides a broadband-like cellular data connections that is 10 times faster than 1*RTT (CDMA) service. With high-speed connection, faster downloading is possible when accessing the Internet. EV-DO is often referred to as Mobile Broadband and cellular Broadband. There are two Raven modems in the Test Vehicle connected to the two laptops. In addition to the primary broadcast and receive antenna port, the Raven-E
EV-DO is equipped with a secondary receiver diversity antenna port, which provides improved bandwidth \(^1\).

![Raven EV-DO modem](image)

**Figure 5.5:** Raven EV-DO modem used in the Test Vehicle.

**Linksys Ethernet Cable/DSL Firewall Router 4 Port Switch/VPN Endpoint**

In the Test Vehicle, there are two Linksys routers available for use. Each router is connected to a laptop computer. The Linksys Ethernet Cable Firewall Router is another Broadband device. Unlike the Raven EV-DO modem, the Linksys router allowed instant Internet access, which enabled quick and easy access when necessary.

The Linksys Instant Broadband Ether Fast Cable/DSL Firewall Router with 4 Port Switch/VPN Endpoint is most ideal for connecting a small group of PCs to a high speed broadband Internet connection or a 10/100 Ethernet backbone. The router can be configured to limit internal users’ Internet access based on URLs and/or time periods-URL filtering and time filtering. For enhanced protection against intruders on the Internet, the router features an advanced state-full packet inspection firewall \(^2\).

![Linksys Ethernet Cable/DSL Firewall Router](image)

**Figure 5.5:** Linksys Ethernet Cable/DSL Firewall Router
CHAPTER 6. COMMUNICATION MECHANISM

The main technique involved with the live data transfer (tracking the truck) between the source computer and destination computer is Batch processing and here FTP server is used as the means of data transfer.

BATCH PROGRAMMING

Batch processing is an execution of a series of programs or jobs on a computer without human interaction. Therefore, since Batch jobs are set up so they can be ran to completion without human interaction, all input data is preselected through scripts or command-line parameters. A script is an executable list of commands created by a scripting language. Some Scripts are executed on a web server for e.g.: Perl, PHP etc. Therefore, it is a list of commands that can be executed without user interaction. This is in contrast to "online" or interactive programs, which prompt the user for such input. Input in this project refers to the file containing the GPS coordinate values. Batch processing allows sharing of computer resources among many users and programs. It shifts the time of job processing to when the computing resources are less busy. Batch processing then does not idle the computing resources with minute-by-minute human interaction and supervision. By keeping high overall rate of utilization, it better amortizes the cost of a computer.

There were three different Batch Programs used throughout this project. The First batch program as displayed in Figure 6.1, was used to change the file format from “.csv” (Comma Delimited Version of an Excel Spreadsheet) to “.xls” (Excel Spreadsheet) extension, as shown in Figure 6.2. When LabVIEW collects the coordinates while the truck is en route, it stores the coordinates in a file with “.lv” format as its extension. When that file is accessed in a Windows environment, it is converted into “.csv” format as extension. The first batch program was used to change the file format from “.csv” to “.xls” extension, which, as mentioned, is an Excel spreadsheet.

![Figure 6.1: Screenshot of the First Batch program](image-url)
The Second Batch program was used to send the information from the truck computer (Source Computer) to the FTP server, as shown in Figure 6.4. As the vehicle begins its specified route (for e.g. Charleston to St. Rose) the GPS coordinates are collected. These coordinates are stored in an excel spreadsheet. This excel spreadsheet is transferred or uploaded from the truck computer to the FTP server by executing the second batch program.

Figure 6.3: Screenshot of the Second Batch program that uploads from the truck laptop (source computer) to the FTP server.
The Third Batch program deals with the transfer of the uploaded excel spreadsheet from the FTP server to the local computer (Destination Computer), as shown in Figure 6.5. As the truck computer sends the file to the server, the second batch program on the local computer is then executed. Upon execution the excel file from the FTP server is downloaded to the local computer for further processing. Under these circumstances, the Batch processing technique is used for the live data transfer.

![Screenshot of the Third Batch program]

**Figure 6.4:** Screenshot of the Third Batch program

**FILE TRANSFER PROTOCOL (FTP) SERVER**

File Transfer Protocol (FTP) is a network protocol used to transfer data from one computer to another through a network, such as the Internet. The person who uses FTP for transferring data is known as a FTP client. A server is a storage place on a network, which is used to store and run various applications and is used as file storage using FTP. A FTP client may connect to a FTP server to manipulate files on the server. As there are many FTP clients and server programs available for different operating systems, FTP is a popular choice for exchanging files independent of the operating systems involved.

In this project, the FTP server is used as the major source of communication for vehicle tracking. Data files are transferred from the experimental truck to the local computer via FTP server.
CHAPTER 7. VEHICLE TRACKING

Tracking the vehicle is the heart and soul of the project. The methodology that we have used to track the Test Vehicle involves a combination of both hardware equipment and software programming.

The main advantage of the design is that the GPS location coordinates from the Test Vehicle are transferred to the destination computer via the server in a matter of “0.9 seconds”. The GPS values from the AgGPS are recorded in the Excel sheet by using the Perl scripts and LABVIEW software. Then these GPS values are temporarily stored in the server and are updated on a real time basis, as the Test Vehicle is moving. The GPS values from the server are instantaneously transferred to the destination computer where the vehicle tracking is actually seen. This is accomplished using the Batch programming. The Raven E modems are used to transmit the data via the internet. We have successfully transmitted the GPS values and we are able to track the Test Vehicle in the destination computer using the MATLAB software programming.

MATLAB

MATLAB is a numerical computing environment and programming language (full coding used for this project is referenced in APPENDIX IV). Created by The Math Works, MATLAB allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces and interfacing with programs in other languages. Although it is numeric only, an optional toolbox uses the MuPAD symbolic engine, allowing access to computer algebra capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis and numeric computation. Using the MATLAB product, you can solve technical computing problems faster than with traditional programming languages, such as C, C++ and FORTRAN.

MATLAB can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis and computational biology. Add-on toolboxes (collections of special-purpose MATLAB functions, available separately) extend the MATLAB environment to solve particular classes of problems in these application areas.

MATLAB provides a number of features for documenting and sharing work. With MATLAB, it is possible to integrate MATLAB code with other languages and applications, and distribute the MATLAB algorithms and applications. These key features include:

- High-level language for technical computing.
- Development environment for managing code, files and data.
- Interactive tools for iterative exploration, design and problem solving.
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering,
optimization and numerical integration.

- 2-D and 3-D graphics functions for visualizing data.
- Tools for building custom graphical user interfaces.
- Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, Fortran, Java, COM and Microsoft Excel.

In this project, MATLAB computing environment is used to generate the Map for the experimental section of the Las Vegas’ Highway (Charleston Boulevard to St. Rose Parkway). After generating, the Map of the experimental section whenever the vehicle is taken in to that particular section it can be tracked and then displayed on the map drawn by MATLAB as demonstrated in Figure 7.1.

![Screenshot of the “Digital Highway” map in MATLAB]

**Figure 7.1:** Screenshot of the “Digital Highway” map in MATLAB

**HOW DOES THE MATLAB CODE WORK?**

1. The Latitude and Longitude values of individual lanes are saved in a map.xls file. The format of the map.xls file is as shown below
2. Save the map.xls file in the as mentioned.
   C:\users\digital highway\documents\matlab

3. Open the MatLab software and save the below code with the filename Demo.m.

   ```matlab
   Demo.m
   clc;
   clear all;
   close all;
   a=xlsread('map.xls');
   x=a(:,1);
   y=a(:,2);
   x1=a(:,3);
   y1=a(:,4);
   x2=a(:,5);
   y2=a(:,6);
   x3=a(:,7);
   y3=a(:,8);
   x4=a(:,9);
   y4=a(:,10);
   x5=a(:,11);
   y5=a(:,12);
   x6=a(:,13);
   y6=a(:,14);
   x7=a(:,15);
   y7=a(:,16);
   subplot(211)
   hold on;
   ```
plot(y,x)
xlabel('longitude')
ylabel('Latitude')
hold on;
plot(y1,x1,'--r')
hold on;
plot (y2,x2,'--r')
hold on;
plot (y3,x3)
hold on;
plot (y4,x4)
hold on;
plot (y5,x5,'--r')
hold on;
plot (y6,x6,'--r')
hold on;
plot (y7,x7)
hold on;

subplot(212)
hold on;
plot(y,x)
xlabel('longitude')
ylabel('Latitude')
hold on;
plot(y1,x1,'--r')
hold on;
plot (y2,x2,'--r')
hold on;
plot (y3,x3)
hold on;
plot (y4,x4)
hold on;
plot (y5,x5,'--r')
hold on;
plot (y6,x6,'--r')
hold on;
plot (y7,x7)
hold on;

demo2trucktrack

4. Save the demo.m file in the path shown below.
   C:\users\digital highway\documents\matlab

5. A sub-program was used which is linked from the main file Demo.m to trucktrack.m. This sub-program is also called a function. Save the matlab file trucktrack.m in the same MatLab folder. Type the below code in the trucktrack.m file and check whether the file is saved in the below path.
   C:\users\digital highway\documents\matlab

   Trucktrack.m
function trucktrack
    %clc
    %clear all;
    %close all;
    b=xlsread('Output.xls');
    x8 = b(:,1);
    y8 = b(:,2);
    for i=1:1:10000000000000000
        %     B=imread('truck1.png'); % get your image
        %     h= axes; % a figure with standard axes pops up
        % axes('position',[y5(i) x5(i) .05
        .05],',Xtick',[],',Ytick',[],',box','on'); % a small box is created, this is the
        % imagesc(B) % the image is drawn in the small axes
        % axis off % make sure no axis labels present
        % axis image
        %     map
        %     hold on;
        subplot(211)
        plot(y8(i),x8(i),',--o',',LineWidth',2,...
            'MarkerEdgeColor','k',',
            'MarkerFaceColor','b',,...
            'MarkerSize',10)
        %plot(y8(i),x8(i),',o-');
        text(y8(i),x8(i),',',
        %     axis([11510.9 11510.9 3600 3610 ])
        %ylim([x8(i)- 0.01  x8(i)+ 0.01 ])
        %maximize;
        %     hold on;
        subplot(212)
        plot(y8(i),x8(i),',--o',',LineWidth',2,...
            'MarkerEdgeColor','k',',
            'MarkerFaceColor','b',,...
            'MarkerSize',10)
        %plot(y8(i),x8(i),',o-');
        text(y8(i),x8(i),',',
        %     axis([11510.9 11510.9 3600 3610 ])
        %ylim([x8(i)- 0.01  x8(i)+ 0.01 ])
        %maximize;
        %     hold on;
    %zoom(1);
    pause(0.09);
    subplot(212)
    plot(y8(i),x8(i),',--o',',LineWidth',2,...
        'MarkerEdgeColor','k',',
        'MarkerFaceColor','b',,...
        'MarkerSize',10)
    %plot(y8(i),x8(i),',o-');
    text(y8(i),x8(i),',',
    %     axis([11510.9 11510.9 3600 3610 ])
    ylim([x8(i)- 0.01  x8(i)+ 0.01 ])
    %maximize;
    pause(0.09);
    subplot(212)
    plot(y8(i),x8(i),',--o',',LineWidth',2,...
        'MarkerEdgeColor','k',',
        'MarkerFaceColor','b',,...
        'MarkerSize',10)
    %plot(y8(i),x8(i),',o-');
    text(y8(i),x8(i),',',
    %     axis([11510.9 11510.9 3600 3610 ])
    ylim([x8(i)- 0.01  x8(i)+ 0.01 ])
    %maximize;
    pause(0.09);
hold on;
plot(y8(i+1),x8(i+1),"--ro","LineWidth",2,...
'MarkerEdgeColor','k',...
'MarkerFaceColor','g',...
'MarkerSize',10)
%
plot(y8(i+1),x8(i+1),"ro-");
text(y8(i+1),x8(i+1),"");
%
axis([11510.9 11510.9 3600 3610 ])
ylim([x8(i+1)- 0.01 x8(i+1)+ 0.01 ])
maximize;
hold on;
pause(0.09);
end

6. Generate the Matlab code. The estimated output is as shown below and this display is the final tracking of the truck.

7. The two sub-graphs in the above figure indicate the different view of the tracking of the truck. The first graph displays the moving of truck on the 14 miles section of the road. The second graph is the zoom-in view.
FLOWCHARTS OF PERL AND VB CODE

Flowchart for Perl Code

- GPS
- Truck Laptop as .lvm File
- Change from .lvm to .txt file
- Change from .txt to excel using Perl code
- Sending excel file to Ftp Server
- Retrieving excel file from server to laptop
- Execute excel file in MatLab
Flowchart for Visual Basic Code

1. GPS
2. Truck Laptop as .lvm File
3. Change from .lvm to .txt file
4. Change from .txt to excel using VB code
5. Sending excel file to Ftp Server
6. Retrieving excel file from server to laptop
7. Execute excel file in MatLab
CHAPTER 8. CONCLUSION

The selected section of fourteen-miles of Las Vegas, Nevada interstate highway has been represented accurately on the map. The static and dynamic parameters describing our selected section of highway including those of GPS coordinates describing lane locations, construction areas as well as other significant infrastructure have been measured within an accuracy of ± 152.4 mm (6 inches). Formats and methods to define the “Digital Highway” so that it can be displayed and used have been developed. In addition, data reduction methods have been developed to identify significant activities and events have been used to define those formats and methods of the “Digital Highway”. A web-based database has been developed in which the real-time data is successfully transferred over the internet from the Source Computer inside the Test Vehicle to the Destination Computer whose position is remotely located. The GPS coordinates we successfully transmitted over the internet to the destination computer on a real time basis, with a time delay of just 0.9 seconds. Defined on the “Digital Highway” web system is fourteen-miles of Las Vegas, Nevada highway, which with the GPS coordinates the moving test vehicle, can be tracked on the graphical display, which was designed using the MATLAB programming. The web-based “Digital Highway” system has been designed to update both the static and dynamic characteristics of its selected section of highway instantaneously. Overall, the information contained in the “Digital Highway” database will be made available to all University Transportation Center (UTC) and Transportation Research Center (TRC) researchers so that it can be applied to future projects for the benefit of the transportation field.
APPENDIX I—GPS FORMATTING

Charleston Boulevard to St. Rose Parkway

L1 R7 Raw GPS data

L1 R1 Formatted GPS data table

L2 R6 Raw GPS data

L2 R6 Formatted GPS data table
### L3 R5 Raw GPS data

<table>
<thead>
<tr>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### L3 R5 Formatted GPS data table

<table>
<thead>
<tr>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### L4 R4 Raw GPS data

<table>
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<tr>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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</tbody>
</table>

### L4 R4 Formatted ZGPS data table

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<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
### L1 R7 Raw GPS data

<table>
<thead>
<tr>
<th>Time since start</th>
<th>Date/Time Format</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>174686.8</td>
<td>0.000000000</td>
<td>38.05129</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.9</td>
<td>0.000000000</td>
<td>38.05128</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.1</td>
<td>0.000000000</td>
<td>38.05127</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.2</td>
<td>0.000000000</td>
<td>38.05126</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.3</td>
<td>0.000000000</td>
<td>38.05125</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.4</td>
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<td>38.05124</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.5</td>
<td>0.000000000</td>
<td>38.05123</td>
<td>115.98782</td>
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</tbody>
</table>

### L1 R7 Formatted GPS data table

<table>
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<th>Time since start</th>
<th>Date/Time Format</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>174686.8</td>
<td>0.000000000</td>
<td>38.05129/115.98782</td>
</tr>
<tr>
<td>174686.9</td>
<td>0.000000000</td>
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<td>174686.5</td>
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<td>38.05123/115.98782</td>
</tr>
</tbody>
</table>

### L2 R6 Raw GPS data

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<tr>
<th>Time since start</th>
<th>Date/Time Format</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>174686.8</td>
<td>0.000000000</td>
<td>38.05129</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.9</td>
<td>0.000000000</td>
<td>38.05128</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.1</td>
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<td>38.05127</td>
<td>115.98782</td>
</tr>
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<td>38.05126</td>
<td>115.98782</td>
</tr>
<tr>
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<td>0.000000000</td>
<td>38.05125</td>
<td>115.98782</td>
</tr>
<tr>
<td>174686.4</td>
<td>0.000000000</td>
<td>38.05124</td>
<td>115.98782</td>
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<td>174686.5</td>
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<td>38.05123</td>
<td>115.98782</td>
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### L2 R6 Formatted GPS data table

<table>
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<tr>
<th>Time since start</th>
<th>Date/Time Format</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
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<td>174686.8</td>
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<tr>
<td>174686.5</td>
<td>0.000000000</td>
<td>38.05123/115.98782</td>
</tr>
</tbody>
</table>

58
<table>
<thead>
<tr>
<th>Time stamp (UTC)</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023-01-01 00:00:00</td>
<td>37.2345</td>
<td>-122.4567</td>
<td>10.3456</td>
</tr>
<tr>
<td>2023-01-01 00:01:00</td>
<td>37.2346</td>
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<td>10.3457</td>
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<tr>
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<td>37.2347</td>
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<td>10.3458</td>
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<tr>
<td>2023-01-01 00:03:00</td>
<td>37.2348</td>
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<td>10.3459</td>
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<td>2023-01-01 00:04:00</td>
<td>37.2349</td>
<td>-122.4571</td>
<td>10.3460</td>
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</tbody>
</table>
APPENDIX II—WEBSITE SCREENSHOTS

Home Webpage screenshot (Listed as Figure 4.5)

About the Digital Highway Webpage Screenshot
Fast Camera Webpage Screenshot (Listed as Figure 4.7)

Fast Camera Webpage Screenshot 2 (Listed as Figure 4.8)
Weather ap screenshot of the North American region

Geographic weather map screenshot
Weather page screenshot

Map demonstration webpage screenshot
RTC videos of geographic mapping screenshot

RTC real-time video screenshot (Listed as Figure 4.6)
Highway demonstration webpage screenshot
MATLAB Code

MAP:
clc;
clear all;
close all;
a=xlsread('map.xls');
x=a(:,1);
y=a(:,2);
x1=a(:,3);
y1=a(:,4);
x2=a(:,5);
y2=a(:,6);
x3=a(:,7);
y3=a(:,8);
x4=a(:,9);
y4=a(:,10);
x5=a(:,11);
y5=a(:,12);
x6=a(:,13);
y6=a(:,14);
x7=a(:,15);
y7=a(:,16);

subplot(211)
hold on;
plot(y,x)
xlabel('longitude')
ylabel('Latitude')
hold on;
plot(y1,x1,'--r')
hold on;
plot(y2,x2,'--r')
hold on;
plot(y3,x3)
hold on;
plot(y4,x4)
hold on;
plot(y5,x5,'--r')
hold on;
plot(y6,x6,'--r')
```matlab
hold on;
plot (y7,x7)
hold on;

subplot(212)
hold on;
plot(y,x)
xlabel('longitude')
ylabel('Latitude')
hold on;
plot(y1,x1,'--r')
hold on;
plot (y2,x2,'--r')
hold on;
plot (y3,x3)
hold on;
plot (y4,x4)
hold on;
plot (y5,x5,'--r')
hold on;
plot (y6,x6,'--r')
hold on;
plot (y7,x7)
hold on;

trucktrack

Tracking The Truck

function trucktrack
%clc
%clear all;
%close all;
b=xlsread('Sample.xls');
x8 = b(:,1);
y8 = b(:,2);
for i=1:1:1000000000000000
    B=imread('truck1.png'); % get your image
    h= axes; % a figure with standard axes pops up
```
% axes('position',[y5(i) x5(i) .05 .05],'Xtick',[],'Ytick',[],'box','on'); % a small box is created, this is the axes to draw in
% imagesc(B) % the image is drawn in the small axes
% axis off % make sure no axis labels present
% axis image
% hold on;

subplot(211)
plot(y8(i),x8(i),'--o','LineWidth',2,...
     'MarkerEdgeColor','k',...
     'MarkerFaceColor','b',...
     'MarkerSize',10)
%plot(y8(i),x8(i),'o-');
    text(y8(i),x8(i),'');
%     axis([11510.9 11510.9 3600 3610 ])
%ylim([x8(i)- 0.01 x8(i)+ 0.01 ])
%maximize;
hold on;
plot(y8(i+1),x8(i+1),'--ro','LineWidth',2,...
     'MarkerEdgeColor','k',...
     'MarkerFaceColor','g',...
     'MarkerSize',10)
%plot(y8(i+1),x8(i+1),'ro-');
    text(y8(i+1),x8(i+1),'');
%     axis([11510.9 11510.9 3600 3610 ])
%ylim([x8(i+1)- 0.01 x8(i+1)+ 0.01 ])
%maximize;
hold on;
%zoom(1);
    pause(0.09);
subplot(212)
plot(y8(i),x8(i),'--o','LineWidth',2,...
     'MarkerEdgeColor','k',...
     'MarkerFaceColor','b',...
     'MarkerSize',10)
%plot(y8(i),x8(i),'o-');
    text(y8(i),x8(i),'');
%     axis([11510.9 11510.9 3600 3610 ])
ylim([x8(i)- 0.01 x8(i)+ 0.01 ])
maximize;
hold on;
plot(y8(i+1),x8(i+1),'--ro','LineWidth',2,...
     'MarkerEdgeColor','k',...
     'MarkerFaceColor','g',...
     'MarkerSize',10)
%plot(y8(i+1),x8(i+1),'ro-');
text(y8(i+1),x8(i+1),"*");

% axis([11510.9 11510.9 3600 3610 ])
    ylim([x8(i+1)- 0.01  x8(i+1)+ 0.01 ])
    maximize;
    hold on;
    pause(0.09);

end
# GPS Input.pl

# 9/12/06
# Tim Dery
# This should take the comma delimited text file output from a GPS device
# as input, and should output a comma delimited text file formatted
# to nicely be imported into Excel.
# Rather than changing info in Excel, this will take care of it
use Text::ParseWords;
use Math::Trig;
use strict;
use warnings;

sub toDecimalDegrees($) { # takes a lat or long in DDDMM.SSSSS format and
converts to degrees decimal
     # I know that my lat and long values go to 6 decimal places.
     my $toConvert = shift;
     my $deg = substr($toConvert, -12, 3);
     my $min = substr($toConvert, -9, 2);
     my $sec = substr($toConvert, -7, 7);
     return ($deg + ($min + $sec/60)/60);
}

sub distance($$$$) { # takes 2 sets of lat & long, returns the distance between them
     in miles
     # logic/some code for this was taken from
     http://jan.ucc.nau.edu/~cvm/latlon_formula.html
     # I need to convert from DDD MM SS to decimal degrees, then those to radians.
     Perl's sin and cos
     # assume radian measures.
     # According to the above reference, West and South are negative angles. I am
going to
     # hard code this to make the lons negative, assuming we will be using this on data
just around here
     my $r = 3963.1;   # in miles
     my $pi = atan2(1,1) * 4;
     my $lat1 = toDecimalDegrees(shift);
     my $lon1 = toDecimalDegrees(shift);
     my $lat2 = toDecimalDegrees(shift);
     my $lon2 = toDecimalDegrees(shift);
     $lat1 = $lat1 * ($pi/180);
     $lon1 = ($lon1 * -1) * ($pi/180);
     $lat2 = $lat2 * ($pi/180);
     $lon2 = ($lon2 * -1) * ($pi/180);
     return (&acos(cos($lat1)*cos($lon1)*cos($lat2)*cos($lon2) +


cos($lat1)*sin($lon1)*cos($lat2)*sin($lon2) + sin($lat1)*sin($lat2)) * $r);
}  
#----------------------------------------------------------------------------------------
#This thing needs to read a line, format it, and print it back. Then loop through whole file  
#----------------------------------------------------------------------------------------
open(INFILE, "gps data.txt") or die "Can't open gps data.txt: $!";
open(OUTFILE, '>'+"GPSFormatted.csv") or die "Can't open GPSFormatted: $!";

my $timeTare = 0;
my $Forties = 0;
my $first = 0;
my $startTime = 0;
my $masterClock = 0;
my $lastTime = 0;
my $startLat = 0;
my $startLong = 0;
my $latOffset;
my $longOffset;
my $foundPeriod;
print "Processing gps data.txt...
";
while (<INFILE>) {   #reads the file line by line
  chomp;
  #print "Just read in this line: \$_\n";
  my @wholeThing = &quotewords('([, \])', 0, \$_); #parses line at ,
  my $timeStamp = sprintf("%.1f", $wholeThing[1]); #takes just 1 decimal place
  my $hours = substr($timeStamp, -8, 2)  - 7; #for Pacific Time Zone
  my $minutes = substr($timeStamp, -6, 2);
  my $seconds = substr($timeStamp, -4, 4);
  #print "MAIN WHILE Master Clock = $masterClock, Time Stamp = $timeStamp\n";
  #print "My time is: $hours : $minutes : $seconds\n";
  #Sets our first time values, used for scaling later------------------------
  if($first == 0) {
    $timeTare = $wholeThing[1];
    $startTime = (((($hours * 60) + $minutes) * 60) + $seconds) / 86400;
  }
  #print OUTFILE "$startTime,\n";
  #print OUTFILE "Unformatted Time,Time since start,Date/Time Format,Lat,Lat,Long,Longitude,Elevation (m),Elevation (ft)\n";
  #finds offset for lat & long; takes the whole number from our decimal
  $foundPeriod = index($wholeThing[2], ".");
  #
$latOffset = substr($wholeThing[2], 0, $foundPeriod);
$foundPeriod = index($wholeThing[3], ".");
$longOffset = substr($wholeThing[3], 0, $foundPeriod);
$masterClock = $timeStamp;

$first++; // Handles our timestamp
#Handles our timestamp----------------------------------
if($timeStamp != $masterClock) { #means we repeated data or lost
  #print "$timeStamp != $masterClock\n";
  #if timeStamps < masterClock, we repeated data. In this case, we do
nothing #as the data will be printed once

if ($timeStamp > $masterClock) { #means we are missing data
  while($masterClock < $timeStamp) {
    print OUTFILE $masterClock, "\n";
    #print "GREATER THAN Master Clock =
$masterClock, Time Stamp = $timeStamp\n";
    $masterClock += .1;
    #print "NOT EQUAL : master clock =
$masterClock, subs = ", substr($masterClock, -4, 1), "\n";
    if(substr($masterClock, -2, 2) == 60) {
      $masterClock += 40;
    }
    if(substr($masterClock, -4, 4) == 6000) {
      $masterClock += 4000;
    }
    $masterClock = sprintf("%.1f", $masterClock);
    #print "$masterClock\n";
  }
}
if($timeStamp == $masterClock) {
  $masterClock += .1;
  #print "ELSE : master clock = $masterClock, subs = ", substr($masterClock, -4, 1), "\n";
  if(substr($masterClock, -2, 2) == 60) {
    $masterClock += 40;
  }
  if(substr($masterClock, -4, 4) == 6000) {
    $masterClock += 4000;
  }
  $masterClock = sprintf("%.1f", $masterClock);
  print OUTFILE "$timeStamp,\n";
  #print "Printing $timeStamp to file\n";
#print "Last Time = $lastTime , TimeStamp = $timeStamp\n";
$lastTime = $timeStamp;
if(($wholeThing[1]*10) % 1000 == 0) { #if the number has "00" at
    $Forties++;
}
my $timeSinceStart = sprintf("%.1f", $timeStamp - $timeTare - (40
* $Forties));
print OUTFILE "$timeSinceStart,";
print OUTFILE $startTime + ($timeSinceStart / 86400), ",";
#Handle Lat/Long-----------------------------
print OUTFILE $wholeThing[2], ",";
print OUTFILE (sprintf("%.4f", (($wholeThing[2] - $latOffset) *
100))), ",";
print OUTFILE $wholeThing[3], ",";
print OUTFILE (sprintf("%.4f", (($wholeThing[3] - $longOffset) *
100))), ",";
#Handle Elevation-----------------------------
print OUTFILE $wholeThing[4], ",";
print OUTFILE $wholeThing[4] * 3.28, 
# the end result I get from this is wrong. I think it's because we are
using such small
# changes, the numbers are getting lost in conversions and
calculations
# i'm going to try this looking at 5 second block chunks
}
}
for(my $i = 0; $i< 9; $i++) { print OUTFILE $wholeThing[$i], ","; }
if($lastLat == 0) { # this is the first case, so we do nothing
print OUTFILE "\n";
} else { #need to calculate the distance between points, prints in feet
    print OUTFILE (distance($lastLat, $lastLon,
$wholeThing[3], $wholeThing[5]) * 5280), "\n";
} $lastLat = $wholeThing[3];
    $lastLon = $wholeThing[5];
    $counter = 0;
} else { $counter++; } 
=end comment

VB Script to convert from Notepad to Excel
------------------------------------------------------------------------------------------------------------------

Imports System.IO
Imports System.Data
Imports System.Data.SqlClient
Public Class Form1
    Dim xlWorkBooks As Excel.Workbooks, xlWorkBook As Excel.Workbook,
Ival As Integer
    Dim xlSheets As Excel.Sheets, xlSheet As Excel.Worksheet, xlApplication As Excel.Application
    Dim xlCellRange As Excel.Range
    Dim excelobj As Excel.Application = New Excel.Application
    Dim oBooks As Excel.Workbooks = excelobj.Workbooks
    Dim osheet As Excel.Worksheet
    Dim osheetDep As Excel.Worksheet
    Dim osheetChk As Excel.Worksheet
    Dim osheetWD As Excel.Worksheet
    Dim sFile As String = Application.StartupPath.ToString & ",File.xls"
Private Sub btnExport_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles btnExport.Click
    If File.Exists(Application.StartupPath.ToString & ",gps_data.txt") Then
        xlApplication = New Excel.Application
        xlWorkBooks = xlApplication.Workbooks
        oBooks.Open(sFile)
        osheet As Excel.Worksheet
        Dim osheetDep As Excel.Worksheet
        Dim osheetChk As Excel.Worksheet
        Dim osheetWD As Excel.Worksheet
        Dim sFile As String = Application.StartupPath.ToString & ",File.xls"
        Private Sub btnExport_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles btnExport.Click
If File.Exists(Application.StartupPath.ToString & ",gps_data.txt") Then
    xlApplication = New Excel.Application
    xlWorkBooks = xlApplication.Workbooks
    oBooks.Open(sFile)
    xlWorkBooks.Open(sFile)
    xlWorkBook = xlWorkBooks.Item(1)
    xlSheets = xlWorkBook.Worksheets
    xlSheet = CType(xlSheets.Item(1), Excel.Worksheet)
Dim fInfo As FileInfo = New FileInfo(Application.StartupPath.ToString & 
"\gps_data.txt")
Dim fs As FileStream = New FileStream(Application.StartupPath.ToString & 
Dim sr As StreamReader = New StreamReader(fs)
Dim r As Integer = 1
While Not sr.Read
    Dim str As String = sr.ReadLine()
    Dim tempStr() As String = str.Split(",")
    Dim i As Integer = 0
    For i = 1 To tempStr.Length - 1
        xlSheet.Cells(r, i) = tempStr(i)
    Next
    r = r + 1
End While
Else
    MessageBox.Show("File Does not exist")
End If
xlWorkbook.SaveAs("c:\Output.xls")
xlWorkbook.Close()
End Sub
End Class
WORK CITED

