Project Plan

EML 4551C – Senior Design– Fall 2012 Deliverable

Team 10 – CISCOR Autonomous Ground Vehicle

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Sponsor Overview

CISCOR or Center for Intelligent Systems, Control, and Robotics. uses engineering knowledge from the Mechanical and Electrical & Computing Engineering fields to develop new systems and implement technological innovations in the area of Intelligent Systems, Control, and Robotics. Their designs are used to solve practical problems in both industrial and governmental applications. As our sponsor, CISCOR will be providing some of the high cost materials and sensors that will be required to make the vehicle autonomous. We have already discussed many of these items with our direct sponsor Dr. Oscar Chuy. The items currently scheduled to be provided and their approximate costs are listed in Preliminary Budget section of this Project Plan.

Preliminary Budget

Sponsor Provided Items

Items	Qty	Unit Price	Total
All-Terrain Vehicle	1	$9,000	$9,000
SICK Laser	2	$5,000	$10,000
Stereo Optical Camera	1	$5,000	$5,000
Micro-Processor Boards	2	$3,000	$6,000
Toughbook Computer	1	$2,000	$2,000
		Total	$32,000

Team Procured Items

Our team will be required to emplace the necessary hardware to automate the vehicle and to provide sufficient mounting and protection for the sensors acquired from CISCOR. The prices and quantities listed below are based on our initial project assessment; future individual system assessment will alter these values.

Items	Qty	Unit Price	Total
Encoders	4	$300	$1200
Actuators	6	$150	$900
Aluminum (Plate)	6’ x 12”x1/8”	$77.21	$77.21
(Bar)	3’ x 4” x 1”	$34.94	$34.94
Bolts, Screws, Washers	n/a	$50	$50
Watertight Encloser	1	$400	$400
Wire, Electrical Fittings	n/a	$50	$50
		Total:	**$2712.15**

Project Overview

The main objective of this project is to design and build an autonomous ground vehicle research platform of CISCOR.

The objective of this project is to take a pre-built, running ATV and retrofit it to have full autonomous locomotion. Making the vehicle autonomous will require electrical, software, and mechanical knowledge. To achieve this objective it will require design and implementation of multiple components that will drive the ATV without the direct manipulation of a human. The components include employing the use of actuators for the steering, braking, throttle, and gear select. Also, retrofitting computer sensors, computers, and encoders will also be required.

By the end of this project, CISCOR will have a fully functioning autonomous ground vehicle for the purpose of pursuing further research in the field of autonomous design.

Project Phase Concept Design

In order to achieve our overall goal of a fully autonomous vehicle, we have systematically broken down the process into phases in order to manage time more efficiently. Four main phases compose the overall goal of our project: Kinematic Model, Encoders, Actuators/Servo Motors, Sensor and Computer Mounting.

Encoders will determine the location of the ATV and assist in directing across an undefined plane to a given destination. Actuators and servo motors will be used to control the four main user inputs: braking, throttling, steering, and shifting. Sensors/cameras will scan and observe the surroundings for the computer to process the path of least resistance and provide the correct input to the controls. Complex programs will allow the computers to read the information gathered from the sensors and make accurate decisions.

Completing each phase will be done by the entire team. As a group the team will approach each phase and move onto the next according to the Gant Chart. This will allow for multiple ideas/suggestions while eliminating the time required for the other team members to review each other's' ideas. Starting with the Encoder Phase and ending with Computer/sensor mounting Phase, the other phases will be approached based on level of involvement (lowest to highest). Ideally the lower involved phases will be completed ahead of schedule and allot for more time for the other phases. This allows time to be utilized to its full content and will help prevent phases being delayed in the designing process.

Quality and efficiency are the two main goals in our phases. Accomplishing this will be approached by a specific process designed for each phase. Our Phase Process consists of 10 steps:

1. Ideation/Selection
2. CAD
3. Physical 3D Model

4. Check Model idea and physical design
5. Improvements (if necessary)
6. Check model again (if modified)
7. Order
8. Manufacturing/Shipping
9. Mount implementation
10. Test

Project Phase Description

Phase I – Kinematic Model

For this phase of the project, a basic kinematic model will be formulated for the purpose of trajectory planning when the ATV become fully autonomous and computer driven. Basic measurements will be taken to include but not limited to the following: wheel track, wheel base, gross weight, turning radius, tire and wheel size. When the following information is collected it will then be placed into ADAMS for kinematic simulation. This will give produce a basic model of the ATV path given an input speed and angel of turning.

Problems that may arise is that this model will be too basic and will not account for multiple terrain. This will be handled in subsequent research and is not the emphasis of this project however it is worth noting that this model will be very basic. Also, acquiring the center of mass of this vehicle might prove troublesome. The group will attempt to make contact with the manufacturer to request this information. In the event that the manufacture does not provide this information, the center of mass will be calculated experimentally. This phase should take no longer than two weeks.

Amount of fabrication time
none low moderate extensive extreme

Amount of Computer Modeling time
none low moderate extensive extreme

Amount of implementation time
none low moderate extensive extreme

Phase II – Encoder Implementation

In this phase of the project, we are tasked with mounting encoders to all 4 axles of the ATV. An encoder is a device that measures the precise speed and distance a wheel travels. We are tasked with mounting the encoders so that the program written to control the AGV will feedback pertaining to its position and speed.

Some of the problems we may encounter in the mounting process will be due to vibration and suspension movement. Due to the off-road usage of the vehicle, the encoders mounted to the drive axles will experience a high amount of vibration. This will be dealt with by ordering encoders designed to withstand this type of environment. Also because of the off-road usage, the suspension will be traveling fairly large distances. This creates dynamic space constraints on the encoders and their respective mounts.

The environment will pose the largest problem to our design. Because the ATV will be traveling through dirt, mud, and water, the encoder will need to be weather proof themselves or be contained within some type of housing to guard them from the elements. The environment will also have an effect on the method of mounting the encoders.

From start to finish, this process should take about two months to maybe five weeks. All timeframes have been exaggerated, so following this process plan should get the project completed ahead of schedule. We have also allocated time past this plan in case any severe problems occur. Also, this timeframe accounts for extended shipping time.

Amount of fabrication time
none low moderate extensive extreme

Amount of CAD time
none low moderate extensive extreme

Amount of implementation time
none low moderate extensive extreme

Phase III – Autonomous Locomotion Implementation

This phase of the project will involve modeling, procuring, and mounting the hardware that will allow the vehicle to be driven autonomously. This will entail mounting actuators, or possibly servos motors that will allow the computer to control the throttle, braking, gear shift, and the steering of the vehicle. The emplaced control systems must also allow a rider to manually operate the vehicle with minimal interference. The control systems should also be compact and low-profile so as not to cause a large negative affect on the aesthetics of the vehicle.

The gear shifting system shall allow a programmed signal to cause the vehicle to be placed into any gear. The implementation of this system will run into obstacles in the form of mounting, envelope of motion, and accuracy. The system must also allow for a rider to operate the vehicle. The logical place to mount this system on the vehicle is directly forward of the gear shifting mechanism. This location is occupied by part of the vehicles plastic shell and does not currently possess an adequate mounting location attached to the frame behind this shell. The ability of the shell to easily deform with stress will make any accurate movement upon the control system impossible to predict. Thus, it will most likely be necessary to remove a portion of the plastic shell and fabricate a sufficient mounting point on the frame for this system. The envelope of the gear shifting system is limited by its location in one of the foot wells of the ATV. For this vehicle to remain rider-operable, the control system must not extend so far aft into the well as to make the rider unable to safely and comfortably rest their leg there. The current status of the gear shifter makes accuracy in the motion of the control system difficult and important. The gear shifter currently requires a large amount of force to move the shifter outside of the current gear, but allows smooth, lightly resisted travel until the next gear position is reached. The danger is that if the force required to change out of the first gear is carried through the motion of settling into the desired gear, the momentum of the shifter might carry it through the shifting resistance into the next gear. Essentially, this would shift the gear shifter two places instead of the desired one. To counteract this, the control system would have to accurately know the position of the gear shifter and be able to control this location precisely regardless of resistance. The required rider operation of the vehicle may be achieved by allowing the rider to control the gear shifting system from a computer. This should not be significantly detrimental to the riders' ability to operate the vehicle.

The throttle control system faces limitations in its ability to accurately control the movement of the throttle and the requirement to allow a rider to operate the vehicle. Due to the small size and location of the existing throttle, the control system will most likely be small and mimic the torque input from a human rider without that mechanical advantage derived from the throttle lever a rider uses. This will require a throttle control system with precise control of its location and the ability to generate a large torque for its size. Preliminary study of the existing throttle suggests that any emplaced throttle control system would most likely severely hamper rider operation of the vehicle. This will necessitate a control system which can be disengaged and somehow removed from the area of operation required by a rider to adequately use the throttle. This disengagement requirement may limit the size and accuracy of the control system.

The existing braking control is located on the handlebars like the existing throttle and thus faces some of the same limitations involving rider operability. Due to the current braking setup, an autonomous braking control system may have to mimic the current human clamping motion input to control the brakes. This may be hard to achieve accurately. The braking control system will be able to use the inherent mechanical advantage provided by the existing braking lever and should be able to use a linear actuator to effect the required braking control but will still require substantial force output and positional control to accurately apply the brakes. This may be hard to achieve with a system which, much like the throttle control, would severely impair a riders' ability to operate the vehicle if left in place. This necessitates a system which can be disengaged and removed from the area of operation of the brake lever. This disengagement requirement may limit the size and accuracy of the control system.

The steering control system may well prove to be the hardest system to implement on the project. Implementation will have to overcome obstacles in the form of disengagement, accuracy, force output, and size and spacing. The existing steering system uses a shaft that runs through many of the vital and bulky components of the vehicles power system. This makes utilizing this part of the steering system unfeasible. Thus, the exposed portion of the steering system above the plastic shell will be the portion connected to by the steering control system. This faces the options of attaching to the handle bars, which would require a large range of motion, large mechanisms, and looking aesthetically unpleasant, or using a system which mounts to the steering shaft directly which would face the difficulties of high torque requirements and a relatively small space to operate within. Either system would need to be of smallest size possible as it will be located in the most visible spot on the vehicle and an ungainly control system will detract greatly from the vehicles overall look. The system must also produce steering movements with very careful accuracy as the forces encountered as the vehicle traverses terrain will attempt to alter the position of the steering system. These forces must be resisted, counteracted, or accounted for by the steering control system to maintain accuracy. This system faces the same rider-operable requirement as the other systems.

The higher forces and larger overall system size may make the disengagement of the steering control system hard to achieve.

Amount of fabrication time
none low moderate extensive extreme

Amount of CAD time
none low moderate extensive extreme

Amount of implementation time
none low moderate extensive extreme

Phase IV – Computer and Sensor Mounting

The last phase required for completion of the main objective is Computer and Sensor Mount Implementation. There will be two laser sensors and one camera mounted to the front of the ATV. Another laser sensor will be mounted on the rear of the ATV. The rest of the mounting is for the onboard process controllers and computers.

One of the biggest problems that will be encountered in the mounting process will be the vibration induced from the ATV. Because the ATV is designed for traveling off road and across rugged terrain our mounts have to be accurate even under extreme vibrations. Due to the vibration requirements selection of material could be a challenge. The material will need to be durable and while at the same time b able to absorb vibrations. The stiffer the material the easier it is for vibrations to pass through the material.

Another problem that may arise is keeping the weather off the computers. The components will need to be waterproofed and sealed so moisture and debris will not affect the system.

Space and mounting platforms will not be an issue due to the large racks on the front and rear of the ATV. In order to complete this phase in the least amount of time and to the upmost quality our phase process will be applied as discussed in Project Concept Design and Detail.

Overall, the Computer Sensor and Mount Implementation Phase should take no more than two months to complete. Again, this is allotting extra time for changes that may need to be made. By following the Project Concept Design and Detail modifications needed should be limited causing the Phase to finish ahead of schedule. Because this is the last phase of the overall objective, it will allow more time to check the final product and make sure all of the goals were met.

Amount of fabrication time
none low moderate extensive extreme

Amount of CAD time
none low moderate extensive extreme

Amount of implementation time
none low moderate extensive extreme