Use of Imaging Devices and Machine Learning Software to Assist in Autonomous Vehicle Path Planning

Project Plan

Team 03

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1. Introduction

1.1 Acknowledgement

We would like to express our gratitude Department of Electrical and Computer Engineering who offer EE 491 class, and because of this, we have an opportunity to work together, communicate together, and learn together. Thank you to the Dr. Joseph Zambreno who is teaching this class.

Second, the project team is thankful to Smart Ag who propose this project to our senior design class. We would also like to thank Mark Barglof and Thomas Antony from Smart Ag who are leading us to do this project, and our adviser Dr. Joseph Zambreno who gives us advice for our project.

1.2 Problem Statement

The Iowa company SmartAg has developed an autonomous tractor system. This tractor is able to use a map of GPS coordinates to autonomously navigate a farm. However, this system works solely off of this precreated map, therefore the autonomous system is not able to react to real time changes in its environment: if a farmer adds a fence after the map is made, the tractor will simply run it over. To solve this problem, SmartAg is proposing the use of an image recognition system which will work in tandem with the path planning map.

To accomplish this task, we plan to use a 360 degree camera to capture information about the tractor's environment in real time. The video from this camera will be fed into an object detection system which will identify if there are any obstacles in the immediate environment. If an obstacle is detected, the system will determine its GPS coordinates from its distance relative to the camera, and add the obstacle to the map so it can be avoided in the future.

1.3 Operating Environment

This will not be a stand alone application and will be dependent on the virtual environment provided by SmartAg. As we are just providing software and no electrical components there will be no weather conditions such as rain or temperature will directly affect our project, but as the tractor will still have to run that would be a consideration of the large scale product. This will be

used in fields which can be dusty and we need to take that into consideration when training our algorithms.

1.4 Intended Users and Intended Uses

This product will be used by SmartAg in their autonomous tractor production with the end client's being large scale production farmers.

As the tractor is being driving by their path planning software detects obstacles through the 360 degree camera, it will then identify if there is a border or fence. Upon detecting and identifying an obstacle as such we will first start to navigate away from said obstacle and then pass the GPS coordinates so the algorithm will avoid that obstacle in the future.

1.5 Assumptions and Limitations

Cost-The camera/sensor and harnessing must be less than $1000.
Power- It will need to be powered by the tractor electrical system.
Datasets- We don't have sufficient dataset which we can use to train our model. Our client has promised that there will be more data available once the harvest season is completed.We are planning to mitigate this issue by capturing more images on our own if needed.
Knowledge of Area- None of us had much experience with any of the technologies associated with the project. This project requires the team to be able to use image processing libraries such as OpenCV and be familiar with neural networks.We intend to mitigate this issue by setting aside training time for getting familiar with the new technologies we are supposed to be working with.
Testing limitations-We will be training our model during the harvest season but by the time we will be testing this it will be the winter season during which the weather conditions will be significantly different.
Hardware Materials - Currently we have access to only one camera and it is difficult to obtain depth information from images from one camera since we can not take pictures from multiple cameras placed at different angles. We also have very little knowledge of the accuracy of the sensors provided by our client.

1.6 Expected End Product and Other Deliverables

At the end of the product, we should have a fully functional object detection system that can identify any object that is within the scope of our dataset or any object that looks similar to another object in the dataset.

In addition, we should also have a depth perceptive algorithm that can find how far an object is relative to the tractor.

2. Proposed Approach and Statement of Work

2.1 Functional Requirements

1. The image processing system shall be able to detect objects such as fence,ditches etc in real time
2. It shall be able to send coordinates to the path planning software to assist in its navigation.

2.2 Constraints Considerations

We have limited experience in the terms of image recognition, machine learning and artificial intelligence so there will be a lot of learning and experience that will have to be built into this project. This project will only last through the end of the spring semester of 2018 and all deliverables will have to be submitted at that point.
We will also have to work closely with our client to ensure that our scope is not too large and taking into consideration that we have undergraduate students working part time.

2.3 Technology Considerations

We will be utilizing OpenCV and Darkflow for our image processing.

2.4 Safety Considerations

As we are working with a process that typically involved human interactions we need to thoroughly test this application to ensure that it will be safe to run autonomously when there could be people around.

2.5 Previous work / literature review

General motors, Tesla , Google cars, John Deere are also working on developing autonomous vehicles. For our project, we will primarily focus on detecting objects and sending the GPS coordinates of the objects to SmartAg's path planner instead of developing a complete autonomous vehicle. We are focusing on specific aspect of the autonomous vehicle(object detection) instead of a complete autonomous vehicle as it is beyond the scope of Senior Design class.

2.6 Possible risks and risk management

There is the risk that we won't be able to accomplish this task. To mitigate the risk we will have a very set project plan with realistic goals and timelines ensuring enough time to properly research.
There is the risk that one of our open apis could be no longer available and we will make sure to research all technologies in depth and have alternative solutions as well.
There is the risk that we can't start collecting and training data until after the harvest season and in that situation we will have to train our algorithm with virtual information about fences to supplement for the different conditions.

2.7 Project proposed milestones and evaluation criteria

Milestones	**Description**	**Planned Date *(tentative)**
Research/Learning	1. Neural Networks 2. OpenCV 3. Darknet	2017-10-30
Experiment with Different Methodologies	1. Test various preexisting image classification and NLP code. 2. Make sure we properly understand this!!!	2018-02-01
Image Recognition System	1. Identify and label objects in the image.	2018-02-28
Position Determination	1. Identifies the labels in the image 2. Determines GPS position of object to be added to path planning map	2018-03-31
Testing	1. Test algorithm and train more as necessary	2018-04-20

2.8 Project tracking procedures

We will meet weekly and separate tasks into two week sprints with tasks based off of previous performance and indication of the future schedule. We should ideally have tasks split so that everyone can do all of their work in the two week sprint.

We are also having a gantt chart to keep track our current schedule.

2.9 Statement of Work

Research and Learning

1. Objective of Task: Become familiar with the tools required for this task, including neural networks, openCV, and darknet.
2. Task Approach: We plan to split the group up into two to three sub teams, each tasked with researching different technologies that will be used in this project. We will share this information with the rest of the team at weekly meetings.
3. Expected Results: All members will have some exposure to the tools required for this project. Additionally there will be experts in different technologies and other members will be able to go to them if specific assistance is needed.

Compare Various Methodologies

1. Objective of Task: Determine which tools and methods to use for the final product.
2. Task Approach: Brainstorm various tools and approaches to complete our end goal. We will create proofs of concept for each, and compare them based on feasibility, ease of use, and effectiveness.
3. Expected Results: Narrow down our options to a primary methodology as well as a secondary one which we can fall back on.

Create Image Recognition System

1. Objective of Task: Create a system that can recognize objects deemed important by SmartAg.
2. Task Approach: We will begin by determining a feasible set of objects we wish to recognize. We will then generate a training set of images and use this training set to train the darknet neural net.
3. Expected Results: Produce a system which can reliable detect a set number of objects of interest in real time.

Determine Object Position from Image

1. Objective of Task: Determine the relative position of an object to the camera based on an image of it and translate this to a GPS coordinate.
2. Task Approach:
    - Identify the object using our image processing system
    - Get the current location of the tractor using the GPS in our tractor
    - Then do an estimate of the distance of the object from our tractor
    - Send the GPS coordinates to the path planner used by SmartAg to assist in path planning

3. Expected Results: Create a system which can take an image with and object identified as an input and produces GPS coordinates representing the images object's location as an output.

Testing

1. Objective of Task: Thoroughly test the image recognition and object positioning systems.
2. Task Approach:
    - Create a test plan
    - Create test cases based on that test plan
    - Perform tests
    - Fix bugs that were identified
    - Perform tests again to determine if the bugs have been resolved
3. Expected Results: Prove that our final product meets SmartAg's criteria by successfully passing all tests.

2.10 Testing requirements considerations

For testing, we will use a John Deere tractor with a 360 degree camera, a NVIDIA GPU, and sensors as our testing equipments. The testing place will be a real farm with different kinds of obstacles, like fence, river, animals, and so on. On occasion, if the weather condition is not good for testing, we will set a similar environment indoor, and test our equipments.

3. Estimated Resources and Project Timeline

3.1 Personnel Effort Requirements

Task	Estimated Hours Required	Description
Research and Learning	120	Since we will be in specialized subteams, each person will be able to focus on a single research area. This assumes that we will have a sufficient understanding of the technologies needed if each person spends 20 hours total researching his/her respective topic.
Compare Methodologies	320	This will be the largest aspect of our project since we will need to brainstorm different methodologies, learn any method specific skills needed to implement them, create POCs for each, and compare them to determine which is the most promising.
Image Recognition System	120	This task will involve expanding on both our training and testing data sets. We will then need to train the system and ensure that it works in real time.
Object Positioning System	150	Depending on whether we decide to do this solely using a single image as data, use stereo images, or use peripheral sensors to assist in this task, it will have various complexities. Since there is currently a lot of uncertainty regarding this task, we want to allot time for any unexpected roadblocks.
Testing	200	Testing will be spread throughout this project and is definitely important, so we intend to spend a significant portion of time on it. Once the bulk of development is complete we will need to come up with narrow tests and tests for edge cases to ensure that we have a reliable

		system.

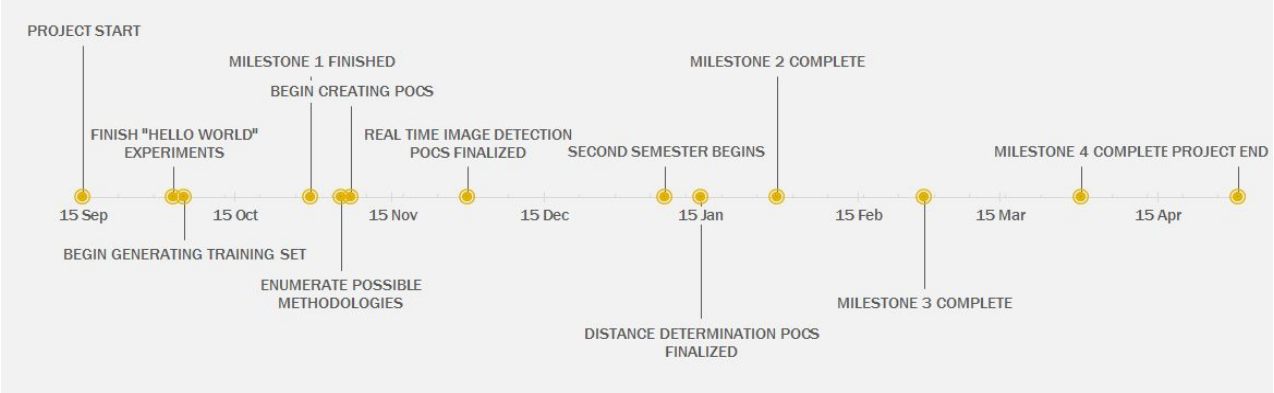
3.2 Other Resource Requirements

- Camera
    - Either 360 degree or stereo wide angle
- GPS
- Modern GPU
- NeuralNet to recognize objects
- Image Datasets
    - Large training set
    - Intermediate testing set for comparisons
    - Smaller testing set
- Peripheral Sensors
    - Radar
    - Lidar maybe

3.3 Financial Requirements

Our overall budget per until cannot exceed $1,000 per unit including software and any additional sensors or materials that we add.

3.4 Project Timeline



4. Closure Materials

4.1 Conclusion

We will be working as a team to improve upon Smart Ag's current path planning software by adding the feature of object detection and image recognition. We will research our neural network options, experiment with different methodologies, implement the image recognition system, implement the distance calculation system, then test. We have a strict deadline with multiple sprints that will be accomplished by sub squads to ensure that we will be working towards our goal with enough time and accountability.
This is a project that our team has prioritized as a high priority and are willing to work hard to complete to full satisfaction as we find this an important project. Technology is the future of the farming industry and being surrounded by an agricultural community this is something that is very close to all team members.

4.2 References

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4.3 Appendices