Project Report on

GPS enabled Autonomous BOT (GABOT)

**Department of Computer Engineering**

**K J Somaiya College of Engineering**

**Overview**

This document contains a detailed report on the undertaken project. It contains the problem definitions, scope, System Requirement Specification (SRS), Software Project Management Plan (SPMP) and the Software Design Document (SDD).

**Target audience**

Project Review Committee

**Submitted by**

|  |  |
| --- | --- |
| Aditya Godambe | 1311020 |
| Chinmay Karanjkar | 1311028 |
| Ashutosh Mahajan | 1311033 |

**Signature of Approval Committee**

# Abstract

GABOT is a primary stage of the driverless motor vehicles that are being developed. The car will analyze its surrounding only up to a particular distance, using the front camera of the car, and then will cover the analysed distance based on the situation, repeating the above mentioned steps every time the analysed distance is covered. The car will be made to change its course upon obstacle identification and follow the further defined course.

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# Existing System

Currently the system consists of:

* Object detection module
* Color detection module
* Partial implementation of robot

# Problem Definition

GPS Autonomous Bot, aka GABot, is a prototype of GPS based driverless vehicle. The GPS here will guide the vehicle from its source to destination. A camera will act as an eye that will capture a video of the path ahead. This video will be then evaluated for obstacle identification. A laptop will be used as the mandatory processor, which will ascertain the non-involvement of any human.

# Scope

* Car will move along a straight-line path.
* It’ll analyze the surrounding up to a particular distance, using the front camera.
* It’ll cover the analyzed distance based on the situation.
* Situations include:
* Obstacles
* Road signs and symbols.
* Car will be made to change its direction based on the situations.
* Analysis will be done by splicing video into frames.

# Proposed System

The system will be pre-fed with a GPS coordinates of the source and destination. Using its camera, it will analyze its surroundings and decide its movements. Along its movements, it will also detect road signs and traffic signals to follow their instructions.

# Programming tools

* Matlab, for Image Processing.
* Arduino IDE, for Arduino Programming

# Hardware and Software platform requirements

The hardware requirements are:

* Arduino chip
* Motors
* Basic robot components like wheels, chassis

The software requirements are:

* Matlab software
* Arduino IDE

# Software Project Management Plan

## Introduction

### Project Overview

The purpose of this project is to implement an autonomous vehicle with no human interference using image processing for object detection and Arduino for hardware control. This project has been inspired by the creation of driverless car designed by Google. This project is being executed as part of our final year curriculum. The expected delivery date is 20th February 2016.

### Project Deliverables

|  |  |  |  |
| --- | --- | --- | --- |
| Sr. No. | Deliverables | Description | Delivery Date |
| 1 | Documents | SPMP: Software Project Management Plan  SRS: Software Requirement Specification  Progress Report  Literature Survey | 19th November 2016  19th November 2016  19th November 2016 |
| 2 | Executable Code | · Code for Background Subtraction  o Using Video  o Using still image  · Traffic Signal Detection  · Road Sign Detection  · Arduino-Matlab Interfacing Code  · Object Detection Code | 26th August 2016      19th November 2016  30th December |
| 3 | Datasets | Sample video for testing | 19th November 2016 |
| 4 | Hardware | The Prototype Hardware Model of the autonomous car | 20th February 2016 |

## Project Organization

### Software Process Model

Prototype and Iterative Model

**The Hardware Component** of the Project will be using the Prototyping model under the evolutionary Process model.

The flow of information and work products:

**Communication:** Discussion about the work product and the deliverables along with different techniques and methods to be used for the deployment and construction of the required deliverable among the developers and the guide.

**Quick Plan:** Sketching of the initial design of the prototype (including the software structure and the hardware structure).

**Quick Design:** Selection of all the appropriate hardware components taking into consideration all the restraints on the system like the size, power requirements, execution and space complexity and the external environment.

**Construction of Prototype:** Assembling all the identified and verified hardware components to construct a prototype model on which the software will be executed.

**Deployment, Delivery and Feedback:** Deploying the robot to near-actual conditions and recording its response. The response recording will include the efficiency of the hardware components, their proper functioning to the software signals, checking the accuracy and robustness of the hardware components.

**Software Component:**

The Software Component of the project will be using the Iterative Process model as the software building and optimization is a repetitive process and will continue till the final deliverable.

**The flow of Information and work products:** Information in form of integrated code and datasets will be carried forward with each iteration of the model. The work products will be based on this information; i.e. the hardware on which the software is executed will be improved with each iteration and with deliverable after every iteration it will include a new feature.

**Review to be conducted:** The working of the deliverable at the end of each iteration will be review for its accuracy and efficiency, along with the checking of function requirement the module is supposed to satisfy. This review will be done by the developers and guide.

**Major Milestones to be achieved:**

* Construction of Robot according to the planned design
* Finalization of Datasets
* Hardware Software interaction and information relay (Arduino-MATLAB interaction library)
* Execution and Testing.

Versions to be established: Versions of the Hardware working module will be released (Within the developing team) as a part of individual feature integration and development.

Project deliverables to be completed: Project deliverables will be the same as mentioned above.

### Roles and Responsibilities

The team consists of four members:

Poonam Bhogle (Project Guide)

Aditya Godambe (Project Planner/Designer)

Ashutosh Mahajan (Project Developer)

Chinmay Karanjkar (Project Tester)

### Tools and Techniques

The development methodologies used in this project are the Prototyping model under the evolutionary Process model for the hardware components and the Software Component of the project will be using the Iterative Process model.

|  |  |
| --- | --- |
| Item | Applied for |
| Language | |
| Matlab | Implementation of image processing algorithms; Interfacing with Arduino for communication with hardware |
| Arduino | Commands to the robot; Interfacing with Matlab for communication with software |
| UML | Design |
| Tools | |
| Matlab software | Writing Matlab scripts |
| Arduino IDE | Writing Arduino code |
| Dia | Designing UML diagrams |
| Microsoft Word | Documentation |

## Project Management Plan

### Tasks

* Tools and resources gathering
* Requirement analysis
* System Design
* Development of an exploratory prototype and getting feedback

#### Task-1: Tools and Resource Gathering

##### Description

All the main requirements of the project both hardware and software are collected in this task. The hardware requirement gathering process will include identifying the correct microprocessors, motor drivers and all the other basic robotic components; Installation of Matlab software and Arduino IDE. It also involves finding relevant technical papers containing algorithms which shall be used for implementation.

##### Deliverables and Milestones

* Finding relevant technical papers containing algorithms which shall be used for implementation.
* Resources needed
* Web resources
* Laptops/PCs
* Access to IEEE Explore library

##### Dependencies and Constraints

None

##### Risks and Contingencies

None

#### Task-2: Requirements analysis

##### Description

Identification of prime functional requirements

* Obstacle detection
* Traffic signal and road sign detection
* Appropriate robotic movement in accordance to the first two requirements.

Software documentation such as SRS, SPMP and STD and hardware feedback logs.

##### Deliverables and Milestones

* Delivery of the current drafts of SRS, SPMP and STD.
* Complete understanding of all the requirements by the group members.

##### Resources needed

None

##### Dependencies and Constraints

Requirement analysis cannot be started until detailed meetings have been conducted with all relevant stakeholders and constraints have been specified.

##### Risk or Contingencies

Possible risks are unclear, less or miscommunication between the technical team and the stakeholders.

#### System Designs

##### Description

This task primarily involves designing the robot’s hardware design and the architecture of the software. These two designing tasks can be sub classified as deciding the chassis design of the robot and designing appropriate UML diagrams.

##### Deliverables and Milestones

* designing the chassis of the robot
* designing the system architecture of the software
* drawing the relevant UML diagrams such as use cases and sequence diagrams

##### Resources needed

None

##### Dependencies and Constraints

The detailed design can't start until the requirements are complete.

##### Risk or Contingencies

Incorrect chassis design main lead to building a low efficiency which does not function properly.

#### Development of exploratory prototype and getting feedback

##### Description

This task involves designing and implementing of the primary modules such as traffic signal and road sign detection, object detection using image processing techniques such as background subtraction. This task also involves gaining and documenting feedback from the exploratory prototype by testing it using the data sets.

##### Deliverables and Milestones

* Traffic signal detection module
* Road sign detection module
* Objection detection module
* Performance observation and feedback documentation

##### Resources needed

* Web resources
* Laptops/PCs
* Access to IEEE Explore library

##### Dependencies and Constraints

Data sets need to be accurate and close to the real environment where the robot will be deployed in order to test the robot as accurately as possible.

##### Risk or Contingencies

Possible risks are incorrect implementation of above modules which may lead to improper functioning of the robot.

Insufficient observation of the robot’s performance may lead to incomplete feedback to the developer does resulting in existence of bugs in the system.

### Assignments

|  |  |
| --- | --- |
| Team Member | Assignment |
| Aditya Godambe | Designing the robot’s chassis; Designing the software architecture; drawing the relevant UML diagrams |
| Chinmay Karanjkar | Verification and validation; Observation and documentation of system performance in target environment and using data sets |
| Ashutosh Mahajan | Implementation of Code for Background Subtraction  o Using Video  o Using still image  · Traffic Signal Detection  · Road Sign Detection  · Arduino-Matlab Interfacing Code  · Object Detection Code |

### Timetable

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sr. No. | Task Name | Duration | Start date | End date |
| 1 | Problem definition | 3 days | 22nd March 2016 | 25th March 2016 |
| 2 | Requirements gathering | 5 days | 26th March 2016 | 31st March 2016 |
| 3 | Discussion of deliverables | 4 days | 4th April 2016 | 8th April 2016 |
| 4 | Project management plan | 2 days | 15th August 2016 | 17th August 2016 |
| 5 | Software Requirements Specification | 5 days | 20th August 2016 | 25th August 2016 |
| 6 | Feasibility analysis | 2 days | 26th August 2016 | 28th August 2016 |
| 7 | Hardware and software design | 10 days | 5th September 2016 | 15th September 2016 |
| 8 | Implementation | 90 days | 25th September 2016 | 26th December 2016 |
| 9 | Testing | 30 days | 28th December 2016 | 29th January 2017 |
| 10 | Manual and documentation | 15 days | 30th January 2017 | 14th February 2017 |
| 11 | Quality checking and feedback documentation | 15 days | 15th February 2017 | 2nd March 2016 |
| 12 | Deployment | 1 day | 4th March 2016 | 5th March 2016 |

# Software Requirement Specification Document

## Introduction

### Purpose

The intended product is a prototype of an autonomous vehicle that is able to navigate and drive on its own without the intervention of a human element. The bot (vehicle) can avoid any obstacles in its path in order to arrive at its destination safely.

### Document Conventions

The priorities mentioned in the functional requirements are in bold for emphasis. Similarly, bold characters are used for emphasis on specific topics.

### Intended Audience and Reading Suggestions

The intended audience is the project review committee and the project mentor.

* **Project Review Committee:** The main focus for the review committee would be the validity and feasibility of the scope of the said project. The review committee may brief through the overview and focus on the system features and other non-functional requirements.
* **Project mentor:** The project mentor may go through the overview of the SRS and may focus more on the external interface requirements, system features and the non-functional requirements.

### Product Scope

The autonomous bot will be mounted with a camera at front which will record a video of the surroundings straight ahead of the bot. It shall then splice the video into frames where each frame will be analyzed to detect the presence of obstacles. Depending on the situation, the car will decide its movement. Situations include – Obstacles, road signs and symbols.

### References

SRS Template:

<https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwilqMLTmrPQAhUIKo8KHVYhBs4QFggZMAA&url=http%3A%2F%2Fwww.csc.villanova.edu%2F~tway%2Fcourses%2Fcsc4181%2Fs2010%2Fsrs_template-1.doc&usg=AFQjCNH5RCUtifVhnKm9Kfwnx6_Z2T5LzA&sig2=6M7DZfJjgaWsXStrx3MwWQ&bvm=bv.139250283,d.c2I>

## Overall Description

### Product Perspective

This product is a prototype of the already in-progress development of self driving vehicles. One of the popular examples of such a vehicle would be that of Google’s self driving car. The proposed product attempts to achieve autonomous behavior similar to Google’s self driving cars on a smaller and feasible scale.

### Product Functions

This product will be able to perform the following functions:

* Detect and avoid the obstacles in its path.
* Identify the type of obstacle (whether it can be overcome or not, e.g. a small bump in its path)
* Identify any traffic signals in front of it and move/stop accordingly.

### User Classes and Characteristics

This product being a prototype of a much larger product does not cater to the needs of any user class. Although, a complete version of the product (real life size model) shall cater to the needs of the general masses in the form of a regular automobile that has the ability to drive to its destination on its own with minimal human intervention. Such a product may me widely used by cab companies to replace their human driven cabs with the new autonomous alternatives. Once completely tested, any user may access the services of the real life product without any special technical/educational expertise.

### Operating Environment

This product shall work on Windows operating system and shall use Matlab as the major operating environment. Apart from this, it shall incorporate the services of hardware components such as Arduino microcontroller, motors, batteries, etc. The image processing shall be performed using Matlab which will be used in sync with Arduino IDE which in turn is responsible for controlling the hardware components of the product. The product shall operate in open surroundings with suitable assumptions and controls.

### Design and Implementation Constraints

Following design and implementation constraints are endured:

* Being a prototype, the entire computation cannot be done on the device itself. Thus the bot shall be connected to a laptop via the USB port in order to perform the complex image processing mechanisms.
* Using small scale motors and batteries, the bot shall use the laptop as the main source of energy.
* Being at a rudimentary stage, the bot shall not simultaneously drive and process its surroundings; the bot shall first process its surroundings and then accordingly move/stay.
* Sudden obstacles cannot be detected.

### Assumptions and Dependencies

Following assumptions and dependencies exist for the product to function:

* Since this product uses many hardware components, the product assumes that each hardware component performs without any errors.
* The video captured by the camera on the bot does not have unwanted ambient lighting (reflections on floor) which may compromise on the product’s ability to process the video frames efficiently.

## External Interface Requirements

### Hardware Interfaces

The software part of the product shall be performed by Matlab which relays relevant information to the Arduino IDE, which in turn controls the microcontroller that controls the motor of the vehicle (bot). This is done by using the in-built libraries that allow communication between Matlab code and Arduino code by the creation of an Arduino object in Matlab.

### Software Interfaces

The major software used is Matlab that runs on Windows operating system. Another software interface that plays an important role is the Arduino IDE which is a development environment for developing Arduino codes. This IDE works in collaboration with the Matlab. Matlab is responsible for processing the video captured by the camera. After processing, the outputs are then checked against appropriate conditions. Accordingly, the relevant output is relayed to the Arduino chip which runs/stops the motor that controls the movement of the bot.

### Communication Interfaces

The product mainly implements the Matlab-Arduino interface for transfer of image processing output data which will be used for manipulating the movement of the bot.

## System Features

### Obstacle Detection

#### Description and Priority

This feature deals with the ability of the bot to detect any obstacle that may be in front of it. Since avoiding collisions with is the prime concern of any vehicle, this functional requirement is **high priority**.

The risk involved with this feature is also a **high priority** risk as it pertains to the purpose of driverless vehicles- safety.

#### Stimulus/Response Sequences

A short video is captured by the camera placed on top of the vehicle. This video is then immediately processed using appropriate image processing algorithms to detect the presence of any object that may hinder the safe movement of the bot.

#### Functional Requirements

1. The camera must capture proper videos of appropriate duration.
2. The bot must be stationary while capturing the video.

### Image Identification

#### Description and Priority

This feature deals with identification of the surrounding that is captured by the camera. This includes identification of traffic signal lights and signs. Since traffic rules are of utmost importance for road safety, this feature is of **high priority.**

The risk involved with this feature is also a **high priority** risk as it pertains to the purpose of driverless vehicles- safety.

#### Stimulus/Response Sequences

This feature deals with identification of the surrounding that is captured by the camera. This includes identification of traffic signal lights and signs. Since traffic rules are of utmost importance for road safety, this feature is of **high priority.**

The risk involved with this feature is also a **high priority** risk as it pertains to the purpose of driverless vehicles- safety.

#### Functional Requirements

1. The color of the traffic light should be correctly analyzed.

## Other non-functional Requirements

### Performance Requirements

The sequential execution of various processes is paramount for safe navigation. The video must be captured and processed in minimal time which in turn reduces the waiting time of the bot. the obstacle (if any) must be detected by the image processing algorithm for the bot to decide whether it should move or not.

### Software Quality Attributes

TBD

## Appendix A: Glossary

* TBD- To Be Decided
* Bot- Robotic vehicle

## Appendix C: To be Determined List

* Software Quality Attributes- adaptability, robustness, reusability, availability, maintainability.

# Software Design Description

## Introduction

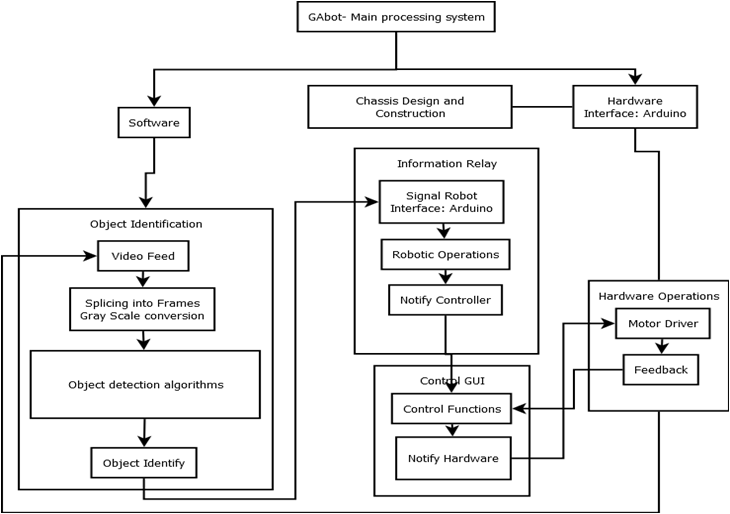
### Design Overview

For the selected project, sequential design principle has been used. This is because the working of the autonomous bot heavily depends on the correct functioning of the a series of activities namely,

* Object identification
* Information relay
* Hardware operations

## System Architecture Design

### Chosen System Architecture



### System Interface Description

The following system interfaces take part in the working of the bot:

* Matlab-Arduino interface: This interface is responsible for exchange of data regarding the movement of the bot. After the video is processed by Matlab, an appropriate output is generated which signals the Arduino chip to relay corresponding movement functions to the Hardware interface.
* Hardware interface: The Arduino controls the functioning of the motor that runs the bot. This is done by the Arduino libraries that allow it to communicate with the mechanical hardware components.

## Detailed Description of Components

### Software: Object Identification

#### Responsibilities-

This component is responsible for capturing the video feed from the camera, splicing it into multiple frames and applying obstacle detection algorithms to perform obstacle detection and identification on the generated series of frames.

#### Interactions-

This component interacts with the camera feed, processes the video and relays germane information to the Arduino component for hardware operations to take place

#### Constraints-

The video is not processed in run time due to computational constraints.

### Information Relay

#### Responsibilities-

This component is responsible for accepting the output from the image processing module (Matlab) and notifies the hardware component of the same.

#### Interactions-

This component interacts with the Matlab code for accepting the output of the processed video. It also interacts with the motors that are responsible for the movement of the bot.

### Hardware Operations

#### Responsibilities-

This component is responsible for driving the motor thereby causing the actual movement of the bot.

#### Interactions

It interacts with Arduino chip receiving control signals that are needed for the movement of the bot.

# Work done in Semester VII and Current Status

* Obstacle detection using Background Subtraction Algorithm
* Testing of Background Subtraction on a number of predefined datasets (short videos)
* Rough chassis design

# Conclusion

From the above literature survey we can conclude that the current autonomous car technology uses a combination of Radar, LIDAR or proximity sensor technology to detect objects and decide movements. With our model we propose a system which uses image processing as an alternative to the above mentioned technologies. Based on the literature survey done, our project incorporates all the necessary features required by a driverless car such as object detection, road sign and traffic signal detection using the algorithms and procedures explained in the chosen papers.

# References

* Anaswara S, Mohan and Resmi, R, “Video Image Processing for Moving Object Detection and Segmentation using Background Subtraction”, IEEE, 2014.