Autobot Racing
Team 21
Anthony Goeckner, Ben Huemann, Zach Perry, Harold Smith

Sprint 2 Planning Document

Sprint Overview

The primary goal of this sprint is integration of the many independent systems developed in Sprint 1 and the realization of basic autonomous driving capabilities.

Scrum Master: Anthony Goeckner
Weekly Meetings will be held on Wednesday evenings and on Mondays at noon.

Risks:

- Potentially unable to find a suitable Kalman filter library.
- Latency between vehicle position/heading identification and control system output potentially too great for useful control to be achieved.
- Track being tampered with while in storage.

Current Sprint Detail

Functional

1. **As a developer, I would like to determine the outline of the track using only a computer vision system.**
    a. Tasks:
        i. Use OpenCV "contour" feature to determine the layout of the track.
        ii. From the edges of the contour, generate a simpler polygon with a minimal number of vertices.
        iii. Determine the navigable areas visible to the camera by finding both the inner and the outer boundaries of the track.
        iv. Test the system in a variety of lighting conditions and track configurations.
    b. Acceptance Criteria:
        i. Given a track with an inner and an outer boundary, the computer vision system will determine the navigable area.
        ii. Given any reasonable indoor lighting environment (incandescent or fluorescent), the track will be accurately identified.

iii. Computer vision will only be used to identify the track during system initialization, at which time the layout will be stored for future use.

c. Assigned To: Zach Perry

d. Workload: 25 hours

2. **As a developer, I would like to control the entire system using a PC or web-based interface.**
    - **a.** Tasks
        - i. Implement API for control and guidance algorithms
        - ii. Implement Camera feed from OpenCV
        - iii. Implement Car Statistics Labels
        - iv. Implement Stop button pop up window
        - v. Test the functionality of API
        - vi. Test the functionality of Camera feed
        - vii. Test the functionality of Car Statistics pop up window
    - **b.** Acceptance Criteria
        - i. Given a Camera Feed the UI will display the feed live
        - ii. Given control and guidance algorithms, the user will be able to select the desired algorithm when adding or editing a car
        - iii. Given a set of cars driving on the track, the statistics label will display performance information for each car
        - iv. Given the stop button click event, a pop up window will appear notifying the user to put the cars back in start position
    - **c.** Assigned to: Harold Smith
    - **d.** Workload: 20 hours
3. **As a developer, I would like a Kalman filter to normalize incoming data from computer vision**
    - **a.** Tasks
        - i. Research possible Kalman filter libraries
        - ii. Import Kalman filter
        - iii. Implement filter into control system design
            1. Accept data and pass to filter
            2. Accept data from computer vision and pass to navigation
        - iv. Test Kalman filter in control system
    - **b.** Acceptance Criteria
        - i. Given input data, Kalman filter accepts the data
        - ii. Given input data, the filter accumulates this data to better normalize new input
        - iii. Given high error input, the filter successfully normalize data and outputs it

   c. Assigned to: Ben Huemann
   d. Workload: 15 hours
4. **As a developer, I would to implement the Integral portion of a PID controller**
   a. Tasks
      i. Research possible ways that the integral portion of a PID controller is implemented.
      ii. Implement the Integral calculation and add to the existing proportional calculation
      iii. Test PID controller with computer vision input
   b. Acceptance Criteria
      i. Given some error, control system is able to maintain a desirable course.
      ii. Given some error and a correction for that error, the control system will display a minimal amount of overshoot.
      iii. Given input, normalized output should be better tuned than the just the stand-alone proportional mode
   c. Assigned to: Ben Huemann
   d. Workload: 15 hours
5. **As a developer, I would like to determine the position of each vehicle on the track.**
   a. Tasks
      i. Cause the computer vision system to poll the camera at a set frequency and determine the location of each vehicle.
      ii. Pass vehicle locations through a Kalman filter. This filter will first be implemented in another user story.
      iii. Implement a function to determine if a vehicle is within the boundaries of the track.
      iv. Store a set number of previous vehicle positions, for use with later control systems.
      v. Determine a system response when vehicle cannot be located.
      vi. Test the system using a variety of vehicles at different locations on the track.
      vii. Test the system response when a vehicle cannot be found.
   b. Acceptance Criteria
      i. Given a single vehicle in view of the camera, its position is accurately recorded.
      ii. Given multiple vehicles in view of the camera, the position of each is accurately recorded.
      iii. Given a moving vehicle, its position is updated with a high degree of accuracy.

    iv. Given the computer vision system and a standard web-camera, a high image sampling rate can be achieved, allowing for a high-fidelity recording of the vehicle position over time.
  c. Assigned To: Anthony Goeckner
  d. Workload: 5 hours

6. **As a developer, I would like to determine the heading of each vehicle on the track.**
   - **a.** Tasks
     - i. Use the vehicle target to determine the vehicle's heading.
     - ii. Pass vehicle headings through a Kalman filter. This filter will first be implemented in another user story.
     - iii. Store a set number of previous vehicle headings, for use with later control systems.
     - iv. Test the system using a variety of vehicles at different locations on the track and pointed at different headings.
   - **b.** Acceptance Criteria
     - i. Given a single vehicle in view of the camera, its position is accurately recorded.
     - ii. Given multiple vehicles in view of the camera, the position of each is accurately recorded.
     - iii. Given a moving vehicle, its position is updated with a high degree of accuracy.
     - iv. Given the computer vision system and a standard web-camera, a high image sampling rate can be achieved, allowing for a high-fidelity recording of the vehicle position over time.
   - **c.** Assigned To: Anthony Goeckner
   - **d.** Workload: 5 hours
7. **As a researcher, I would like to create a guidance system that allows for passing/overtaking behaviors.**
   - **a.** Tasks
     - i. Create a new version of the wall-following guidance system that allows for variable distance from the wall.
     - ii. Determine distance from one point on track to another. (Not the straight-line or Euclidean distance)
     - iii. Increase or decrease the vehicle's distance from the wall when it is within a set track distance of the next car in front of it and its speed is faster than the car in front.
     - iv. Test the system using the ControlSim application developed in Sprint 1.
     - v. Test the system using the real vehicles and track, if possible.
   - **b.** Acceptance Criteria

            i. Given an overtake situation where vehicle A is gaining on vehicle B, the distance from the wall of vehicle A is appropriately adjusted for passing.
            ii. Given an overtake situation when the slower vehicle is on the inside of the track, the overtaking vehicle's distance from the wall will be increased.
            iii. Given an overtake situation when the slower vehicle is on the outside of the track, the overtaking vehicle's distance from the wall will be decreased.
    c. Assigned To: Anthony Goeckner
    d. Workload: 20 hours

8. **As a developer, I would like to run the control and guidance algorithms using data passed from the computer vision system.**
    a. Tasks
        i. Integrate control and guidance algorithms with the rest of the Autobot Racing system.
        ii. Pass output of control systems to the vehicle transmitters.
        iii. Test the complete integrated system with one vehicle.
        iv. Test the complete integrated system with multiple vehicles.
    b. Acceptance Criteria
        i. The full Autobot Racing system and the ControlSim simulator should use the same control/guidance algorithm codebase.
        ii. Given a single vehicle test, the vehicle should successfully navigate the track.
        iii. Given a multiple vehicle test, the vehicles should all successfully navigate the track, barring any collisions between vehicles due to a lack of overtaking capabilities in the guidance system.
        iv. Given the complete integrated system, delay from computer vision vehicle identification to control system output must be negligible.
    c. Assigned To: Anthony Goeckner
    d. Workload: 10 hours

9. **As a developer, I would like to write a GPIO-based driver to control the vehicle transmitters.**
    a. Tasks:
        i. Determine GPIO pins needed and initialize them
        ii. Retrieve messages from communication socket
        iii. Send to message data to control function
        iv. Create three separate controlling functions
            1. Speed(float)

a. Set appropriate pin to digital potentiometer to control Speed of RC car

2. Turn(char)
    a. Set appropriate pin to turn the car left, center, or right

v. Test speed function
vi. Test turn function

b. Acceptance Criteria
  i. Given message is received, then data is sent to the appropriate function
  ii. Given the speed function is called, the RC car will change its speed according to data passed to it
  iii. Given the turn function is called, the vehicle will turn its wheels

c. Assigned to: Ben Huemann & Zach Perry

d. Workload: 5 hours each, 10 total

10. As a developer I would like to run a multithreaded system

a. Tasks:
  i. Create main thread for UI and Framework
  ii. Create thread for OpenCV
  iii. Set locks on any shared values to maintain concurrency
  iv. Test threads to ensure they run concurrently
  v. Test that threads run concurrently without errors

b. Acceptance Criteria
  i. Given a thread for UI and Framework, the thread functions as normal
  ii. Given a thread for OpenCV, the thread functions as normal
  iii. Given a function or variable accessed by multiple threads, a lock will be set on the function or variable to ensure concurrency between threads

c. Assigned to: Harold Smith

d. Workload: 10 hours

11. As a developer I would like a message queue for each thread to allow communication

a. Tasks:
  i. Create message queue for main thread
  ii. Create message queue for OpenCV thread
  iii. Test that complete messages are received in a timely fashion.

b. Acceptance Criteria
  i. Given a well formed message when sent then the message should be received at the destination
  ii. Given a well formed message when sent then the message should be received in a desired time
  i. Given a high volume of data traffic through the message-passing system, all messages will be delivered reliably and in a timely fashion

- **c.** Assigned to: Harold Smith
- **d.** Workload: 10 hours

12. As a developer, I would like to connect each Raspberry Pi to a RC transceiver so a PI receives control of the RC car

- **a.** Tasks:
  - i. Take apart each remote
  - ii. Measure & record voltages/resistance of the buttons, potentiometer, and power connections
  - iii. Desolder and remove buttons, potentiometer, and power wires from circuit board
  - iv. Solder new wires to striped buttons, potentiometer, power nodes so that the PI gains control of the transceiver
  - v. Choose GPIO pins and connect the new wires to the pins
  - vi. Test conductivity between all new leads soldered to wires
- **b.** Acceptance Criteria
  - i. When the PI sends power to the power pins, the LED on the transceiver should light up signifying it is receiving power
  - ii. When the PI sends power to either the left/right buttons, the wheels on the RC car should turn accordingly
  - iii. When the varying current is sent to the potentiometer nodes, the car should accelerate, stop, or reverse according to current draw
- **c.** Assigned to: Ben Huemann & Zach Perry
- **d.** Workload: 5 hours each, 10 total

Non-Functional

1. As a researcher, I would like to create and set-up the track and camera.

- a. Tasks:
  - i. Source track material
  - ii. Create track layout
  - iii. Mount camera to tripod
  - iv. Place Tripod in track
- b. Acceptance Criteria:
  - i. Given a track, the camera must be able to see the track without the tripod interfering with the track.
  - ii. Given a track, the material must be laid in a way that allows the cars to handle well
  - iii. Multiple track layouts must be provided to prove modularity and show that the tracks of the cars are not hard-coded or pre-determined

c. Assigned to: Zach Perry
d. Workload: 5+ hours

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Backlog

Functional Requirements:

As a researcher...

- I would like to implement autonomous lane-keeping behavior.
- I would like to implement speed-holding behavior.
- I would like to implement automatic braking behavior.
- I would like to implement automatic acceleration behavior.
- I would like to implement immobile obstacle avoidance. (if time allows)
- I would like to implement moving object avoidance. (if time allows)
- I would like to record race statistics, such as lap times.

As a developer...

- I would like to determine the course followed by the cars, including the course around obstacles.
- I would like to control a minimum of three cars simultaneously.
- I would like to identify immobile obstacles using computer vision. (if time allows)
- I would like to identify moving obstacles using computer vision. (if time allows)

Non-Functional Requirements:

As a developer...

- I would like to have code that is sufficiently documented and well formatted.
- I would like code that is modular and built to accommodate updates in the near or far future.
- I would like the application programming interface (allowing researchers to control cars) to be flexible and well-designed.

As a project owner...

- I would like hardware costs to be reasonable and well-controlled.
- I would like for off-the-shelf hardware to be used in development, in order to decrease construction costs.

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Sprint 2 Workload Distribution

Team Member	**Hours**
Anthony Goeckner	40
Ben Huemann	40
Zach Perry	40
Hal Smith	40