NASA LEC Robotic Mining

1.0

Requirements Document

September 2020

By: Taylor Ertrachter, Bailey Hamant, James Spies

Table of Contents

Table of Figures & Tables

1 Overview

1.1 Scope

The NASA LEC robot is created to traverse a course with obstacles in the way, get to a mining point, mine the right material, and leave the course. Movement will be done automatically, or manually if needed, to get through the obstacle course without getting stuck or hitting any of the obstacles. Wheel movement consists of forward and backward, as well as left and right. Mining material involves two arms moving the conveyor belt down to the minerals, and the belt starting up to pick up the minerals. The conveyor belt stops when there are no more minerals left to pick up or the storage area is full. The robot will leave the mining area in the same way it got there.

1.2 Events

The NASA LEC robot has both automatic and manual events. Manual events include moving the wheels, moving the arms, and starting and stopping the conveyor belt. Automated events are the same actions, but with different calls to start them.

Manually moving the wheels includes using a controller to move the robot forward and backward, and turning left and right. Manually moving the arms means using a controller to raise or lower the arms holding the conveyor belt to start or stop the process of moving. Manually starting and stopping the conveyor belt means starting or stopping the process of moving mining minerals and bringing them to the storage area.

Automatically moving the wheels means the system sending a signal to the robot to move forward, backward, left or right, based on what it sees in the camera feed. Automatically moving the arms means that when the robot knows it is time to start mining it lowers the arms, and when it is done mining it raises the arms. Automatically starting and stopping the conveyor belt means that after the arms are lowered, the belt will turn on to start the mining process, and the belt will stop when the storage area is full or there is nothing left to mine. Stopping the conveyor belt is the signal to raise the arms.

2 System Life Cycle Processes

2.1 Subsystems

2.1.1 Wheel Navigation

Each wheel is being controlled independently by a motor. Each motor will need to be programmed to uniquely perform their functions in order to correctly move the robot in the direction needed. A failure for any requirement in this section would have the motors moving out of sync for the direction requested by the Onboard Computer.

Functional Requirements	
FR 1	The robot shall be able to take a gradual left and right turn. In order to take a gradual left turn, the front wheels will need to be able to be angled to the left while all four wheels are being moved forward. In order to take a gradual right turn, the front wheels will need to be able to be angled to the right while all four wheels are being moved forward.
FR 2	The robot shall be able to move forward and back with no turn or angle applied to the front wheels. In order to move forward, the four wheels will need to move forward. In order to move backwards, the four wheels will need to move backwards.
FR 3	The robot shall be able to take a left or right turn instantly by moving in a full or half circle. In order to take an instant turn to the left, the wheels on the left side of the robot will move backwards while the wheels on the right side of the robot will move forwards. In order to take an instant turn to the right, the wheels on the right side of the robot will move forwards while the wheels on the right side of the robot will move backwards.

Table 1 - Functional Requirements for Wheel Navigation

2.1.2 Camera

Functional Requirements	
FR 1	For sample collection and collision avoidance, the camera shall to detect objects found on the competition field. The onboard computer will have a library of what are objects to avoid and what are samples to collect.
FR 2	According to the competition rules, there are different categories of samples the robot is able to collect, all of these samples have different colors to set them apart. A priority queue shall be implemented to the main algorithm on the onboard computer to order the weight of these samples based on a predetermined strategy. The robot will choose which samples are worth traveling to in a certain order by recognizing their color.
FR 3	In order for the robot to move autonomously without running into any objects and to line itself up to appropriately be able to pickup samples, it will need to know the distance between itself and key objects.
FR 4	Since the competition course will be simulating a planet's surface, lighting will not be even throughout the competition. The camera will need to do all of the requirements listed above in varying amounts of light.

Table 2 - Functional Requirements for Camera

2.1.3 Sample Collection Conveyor Belt

Any failure encountered in this section of requirements will result in failure to secure points for the robot.

Functional Requirements	
FR 1	In order to transfer samples from the floor to the collection bin in the robot, the conveyor belt will need to be able to pick up the sample and move it up the belt and into the collection bin. Alternatively, if it rejects a sample once it is in the collection bin, it will need to be able to move the sample down the belt and back on the floor.
FR 2	The robot will need to be able to pick up samples from the floor. Assuming the robot has been appropriately lined up, a ledge from the conveyor belt will catch on to the sample when it is moved up.
FR 3	The arms holding the conveyor belt will move up and down.

Table 3 - Functional Requirements for Sample Collection Conveyor Belt

2.1.4 Jetson Onboard Computer

The onboard computer that will be running the main program of the robot is the NVIDIA Jetson, and will be referred to as the Jetson in these requirements.

Functional Requirements	
FR 1	The Jetson will need to act as the coordinator between the subsystems and appropriately turn on and off subsystems as needed by the system. Failure to coordinate the subsystem processes correctly will result in a complete breakdown in robot function.
FR 2	In case of an emergency situation where the robot cannot be controlled and is about to damage itself or someone else, the robot will need a kill switch that immediately shuts down the Jetson and all subsystems activated. If there is no killswitch implementation or it does not correctly shut the system down, it would cause serious damage to the robot, course, or persons.
FR 3	The Jetson will need to produce a Bluetooth signal that connects to a Bluetooth remote controller and be able to receive commands from the controller. This signal will need to be strong and continuous from both the Jetson and the controller. Should either device lose signal, it will be impossible to control the robot wirelessly.
FR 4	The robot ultimately will have automation implemented. There is no huge failure should this feature not get implemented as it is labeled as a “stretch” goal by both the client and our team.

FR 5	The Jetson will need to produce a WiFi signal that will allow WiFi enabled devices to connect to it and access a website that will be broadcasted off of the Jetson. This website will contain important debug information on the current status of the robot in general, and all subsystems active on the robot. This signal will need to be strong and continuous from both the Jetson and the device connected to it. Should either device lose signal, it will be impossible to get this information from the robot.

Table 4 - Functional Requirements for Jetson Onboard Computer