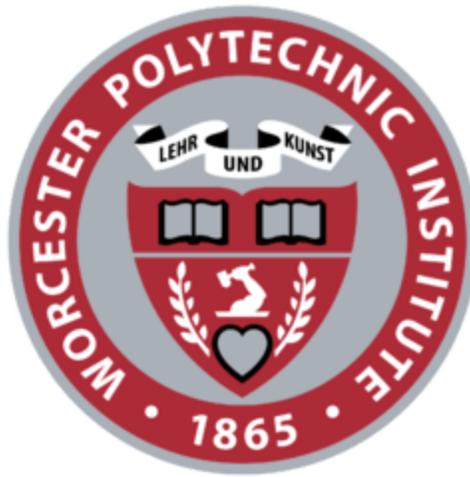# Software Sequence Model

NASA Lunabotics MQP 2019-20

Internal Documentation

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3. Digger Motor (Also used for the primary conveyor)
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Computational
1. Jetson
2. ODrive Controller

Visual
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2. RealSense Rear
3. IR Sensor

User
1. User

Standard Events

Event: Orientation
>**Actors:** RealSense Front, RealSense Rear, Drive Motor 1, Drive Motor 2, Jetson,
>**Description:** Orient the robot to face the digging zone.
>**Exceptions:**
>>1. Motor Malfunction
>>2. Cannot be certain about heading
>
>**Post Condition:** We can begin the run if we have a high confidence that the front facing camera is facing the dig zone.

Event: Navigate to digsite
>**Actors**: Realsense Front, RealSense Rear, Jetson, ODrive Controller, Drive Motor 1, Drive Motor 2
>**Pre-Condition**: Defined orientation on manual setup. Digger up, Front-facing, and in front of the dumpsite
>**Description**: The robot needs to analyze the field using its camera. Identify a path to proceed, and send the commands to the jetson for distribution to the motors. (Do we want to do course correction here, or do we want the jetson to ask for directions more frequently?). The robot must iterate over this process until the front of the machine is over the digging line, and the digger is facing the correct way. Drive into the dig site until the rear camera can pick up the dig line **Potentially mapping the reverse path with the back camera**
>**Exceptions**:
>>1. Stuck in an obstacle
>>2. Stuck on an obstacle
>>3. Stuck on the wall
>>4. Motor Failure (can be refined)
>>5. Poor orientation
>>6. Too far into the digging zone
>>7. Not following the pathing (slippage, etc)
>
>**Post Condition**: The bot has entered the dig area so far that the Rear Camera can see the dig line, and the bot is perpendicular to the dig line.

Event: Dig
>**Actors**: Jetson, Digger Motor, Digger O Drive Controller, 4-Bar motor, 4-Bar O Drive Controller, Drive motor 1, Drive motor 2, Drive O Drive Controller, IR capacity sensor
>**Precondition**: In position at digsite
>**Description**: The robot neets to send commands from the jetson to lower the 4 bar linkage with the digging wheel and begin digging. The robot will dig and continuously lower the 4-bar linkage until it reaches a specific angle. The robot will then

drive backwards After theIR Capacity sensor registers enough collected material, the jeston will command the digging wheel motor to stop and lift the 4-bar linkage.

Exceptions:
1. Motor failure on 4-bar linkage
2. Motor failure on digging wheel/conveyor
3. Object stuck in bucket
4. Stuck in hole
5. Digger Wheel Jam
6. IR Vision Blocked

Post Condition: The IR sensor confirm that the desired amount of material has been collected, and the 4-bar linkage is pulled up with digging arm no longer in the ground.

Event: Navigate to dumpsite

Actors: RealSense Rear, Drive motor 1, Drive Motor 2,

Precondition: The desired fill line has been reached for this iteration. The digger and primary conveyor are off, and have been returned to the travel position.

Description: During this phase, the robot must navigate back to the drop off location. The robot will drive in reverse, using the rear camera to path find. We will use a series of aids to help the robot navigate back more swiftly. They may include track tracing, and pure path analysis. Then, navigate the robot to be flush with the back wall so that the conveyor can properly deposit the material into the drop off zone.

Exceptions:
1. Slippage (Consider the extra weight)
2. Falling into the freshly dug hole
3. Not flush against the drop off point
4. Cannot Identify the dump site

Post Condition: Both of the non-sensor bumpers are against the wall of the arena, and the secondary conveyor is positioned within the width of the drop off location.

Event: Dump

Actors: Conveyor Motor,RealSense Rear

Precondition: Both drive motors indicate that the two non-sensor bumpers are pressing against the edge of the arena. There is confirmation from the camera that the conveyor is in between the edges of the collection bin.

Description: Turn on the conveyor until the IR sensor reads that enough material has exited the bot, and has been deposited into the collection bin.

Exceptions:
1. Motor Exceptions
2. The material is under-shooting the collection bin
3. The material is over-shooting the collection bin

4. The conveyor is not properly removing the material from the bot
5. The IR camera cannot detect the level required to stop the deposit

Post Condition: The robot has been emptied of all icy regolith.

Exception Events

Event: Motor Malfunction Check (Drivetrain)

    Actors: Affected Drive Motor(s), RealSense Front, Real Sense Rear

    Precondition: Camera detects that we are not moving on the intended path, or incorrect voltage readings from the motors.

    Description: Check that the motor is still reachable by pinging status. Send a series of speed values until the camera detects movement. Stop motor.

    Exceptions:
1. No motor response
2. Disconnected wire (Fatal Exception)
3. Speed not scaling properly due to eternal conditions

    Post Condition: The robot is able to re-execute previous command.

Event: No Motor Response

    Actors: Affected Motor

    Precondition: Motor is not responding to commands given

    Description: Stop all running commands and begin safe shutdown sequence for all components (Save all robot states). Software-ily disconnect and reconnect affected motor.

    Exceptions:
1. Motor doesn't reconnect
2. Previous Robot State not read correctly

    Post Condition: Motor is reconnected and operational

Event: Cannot determine initial orientation

    Actors: Drive motor 1, Drive motor 2,

    Precondition: The bot cannot confidently orient itself to face the digging zone**.**

    Description: If the bot cannot get its bearings, the only means of correcting the issue is intervention. The team will have to use the data from either the cameras on board, or the arena cameras in order to tele-op the robot to face the correct direction. Once the bot is facing the correct direction, we will continue the autonomous operation after the point of confirmed orientation.

    Exception:
1. One or more of the cameras have failed
2. Tele-Op connection error

    Post Condition: The bot is facing the correct direction and is ready to resume autonomous control.

Event: Stuck in an obstacle

    Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Front or

Rear

Precondition: The Robot has received information from either the motor, or the camera that has indicated that it is not currently on the mapped path for the executed movement.

Description: During this event there will be several ways to detect that the desired movement sent to the wheels is not the same as is being sensed by the robot. When the discrepancy is discovered. We must stop moving, and decide which action to take. First, we should reverse the previous commands, while monitoring the path to make sure that we are not stuck, just running into an obstacle.

Exception: Stuck in an obstacle rather than stuck on one.

Post Condition: We have a new path for successful traversal of the obstacle course.

Event: Stuck on an obstacle

Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Front, or Rear

Precondition: We have detected, through any of the available sensors, that we are not moving on the predicted path given the commands sent to the motor. We have attempted to back away from the obstacle, but have determined that we are stuck in the obstacle rather than on it.

Description: This event is a more complex event of the same type as the 'stuck on an obstacle. This event will only run once we have determined that the protocol for the previous event does not work to get the bot back on track. There are several things we can do here based on testing. Ideas include: Pulsing between forward and reverse to try to shake free of the crater. Using the digger arm to push the bot backwards out of the hole.

Exception: Remaining stuck after implementing escape protocol.

Post Condition: We have returned to the desired path, oriented, and are free from the obstacle, that is, the motor commands result in expected movement.

Event: Stuck on the wall

Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Front, or Rear

Precondition: We have detected that the movement of the bot does not correspond to the expected movement given the most recent command to the motors.

Description: Follow the same protocol as the 'stuck on obstacle' event.

Exception: Late detection

Post Condition: Pathing has accounted for the obstacle. Oriented. Motor commands are resulting in expected movement.

Event: Poor orientation

Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Front, Real

Sense Rear

Precondition: The Bot cannot confidently determine that the digger wheel end of the bot is facing the mining section of the arena.

Description: This event will need to be addressed by moving incrementally, avoiding objects, until the reflective tape can be confidently detected by either of the cameras. The pattern for incremental movements will be determined after testing.

Exception: The line is not found after a reasonable amount of time.

Post Condition: The dig zone has been sighted, and the bot is oriented towards it.

Event: Too far into the dig zone

Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Rear

Precondition: The bot has traveled too far into the dig zone, and the digger wheel cannot deploy.

Description: We must reverse until the digger wheel can deploy uninhibited by the back wall of the arena. We can confirm not over correcting with the Rear RealSense

Exception:
1. Over corrected.

Post Condition: The digger wheel can successfully deploy, and the bot is still acceptably far from the edge of the digging zone.

Event: Slippage

Actors: Drive Motor 1, Drive Motor 2, O Drive Controller, Jetson, Real Sense Front

Precondition: The bot is not on the desired path calculated with the image processing data.

Description: The bot will have several ways to discover slippage. (SOMEONE RBE HELP). Between motor readings, encoders, and the cameras we will be able to detect any inaccuracies in bot movement. We can correct for these inaccuracies real time so that we can save previous paths, and follow the predetermined one.

Exception:
1. Incorrect correction
2. Complete slippage

Post Condition: The correct mapping of the actual path the robot is on.

Event: Bucket Clog

Actors: NA

Precondition: There is a bucket that is not transferring the material it digs to the conveyor.

Description: Efficiency drops, but there is nothing we can do.

Exception: NA

Post Condition: NA

Event: Primary Conveyor Jam
    Actors: Primary Conveyor Motor.
    Precondition: The Primary conveyor Motor is being over torqued.
    Description: Oscillate the motor and periodically test until the voltage readings are
        acceptable.
    Exception:
      1. The motor cannot unjam. (Fatal)
    Post Condition: The Primary conveyor motor is working properly.

Event: Digger Wheel Jam
    Actors: Primary Conveyor Motor.
    Precondition: The Primary conveyor Motor is being over torqued.
    Description: This will be non differentiable from the previous exception. However, we
        will need to raise the wheel to determine if the jam is something in the
        environment, or if the jam is on board the bot. If lifting the digger wheel resolves
        the jam, then we need to enter protocol for finding another digging location.
    Exception:
      1. The motor cannot unjam. (Fatal)
      2. The digger wheel cannot raise. (Fatal)
    Post Condition: The Primary Conveyor motor is working properly.

Event: Teleop Connection Error
    Actors: Tele-OP, Jetson
    Precondition: Upon trying to connect via tele-op we get any error.
    Description: Try reset. Else fatal error.
    Exception: Cyclical
    Post Condition: Re-established working tele-op connection.

Event: Camera Failure
    Actors: RealSense Front, RealSense Rear
    Precondition: One or more of the cameras are not functioning as expected, or are not
        functioning at all.
    Description: If only one of the cameras is down, we need to establish a single camera
        mode. This will involve more turns upon switching between the 5 main tasks.
        (May not be possible if the rear camera is out and we need to perform a drop
        off.). Otherwise, if both cameras malfunction, we need to turn on arena cameras,
        and finish the mission via tele-op.

        We can also try a camera reset.
    Exception:

1. Tele-op connection error
2. Orientation errors

Post Condition: The Robot is in functioning condition with one or less cameras operational.