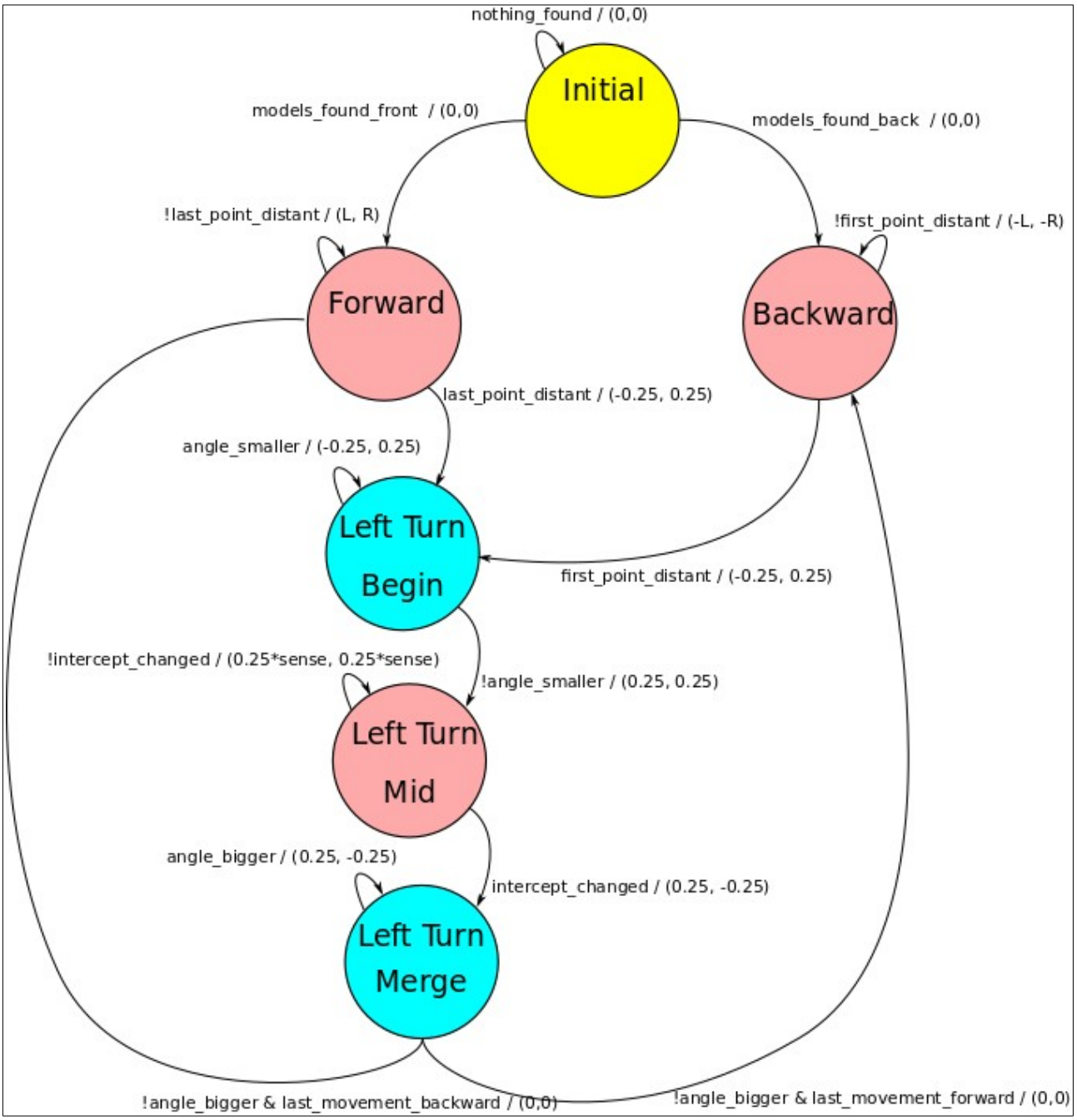
Robot State Machine

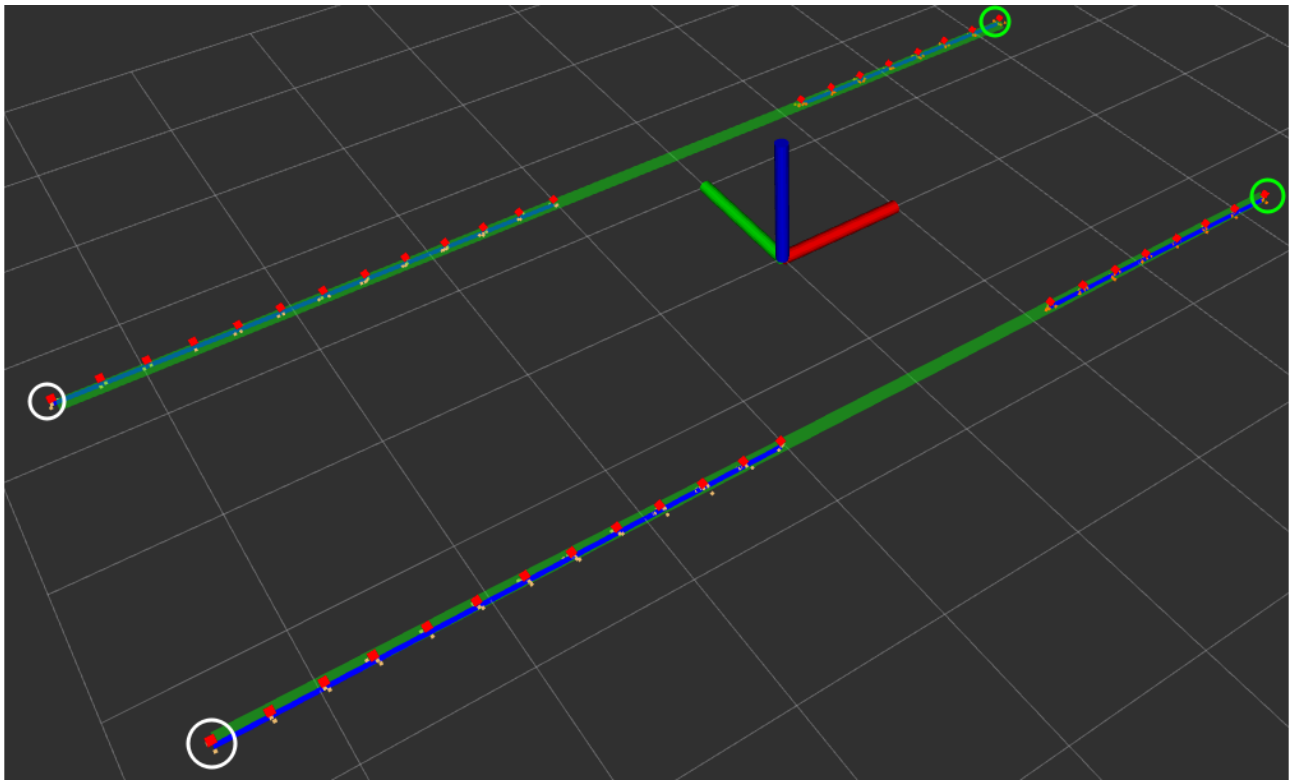


Notation: **States** are written in Bold, *variables* are written in italic

This chart shows how the Finite State Machine (FSM) works in a simplified manner. The first thing that you have to keep in mind, is that the red painted states always have an intermediary state called **Linear Stop** and the blue painted states have **Angular Stop**, to guarantee that the robot will not have overlapping velocities and movement. The *nothing_found* transition for each state was omitted to simplify the drawing, so keep in mind that all the states have a transition that goes to the Initial state if *nothing_found* is triggered. The notation used for this chart is the Mealy state machine notation “condition / output” where output is (Left_wheel_command, Right_wheel_command).

➢ *Background*

This state machine controls the robot's movement, receiving as input the models selected. The algorithm that finds the models and the one that selects and synchronize are out of the scope of this document. Once the models are found (the green lines in the image below) we have a pair of models where the first one is the Left line that has a positive intercept and the second one is the Right line with negative intercept. Each model contains its first point, represented as the white circle, and the last point, represented as the green circle. Always keep in mind that the robot is always the Cartesian's plane origin, meaning that if it rotates anticlockwise the lines will appear to rotate clockwise.



➢ *Initial State*

The initial state is the simplest one. Since the robot does not know if it must move forward or backward nor where or how to move, it stays still waiting for lines to be found, thus *nothing_found* is set. If the robot finds one line it decides if it has to go backwards if the last point of the model is negative, *models_found_back* is set and the transition is made to **Backward**, else as a default sense of motion *models_found_front* is set and the transition is made to **Forward**.

➢ *Forward State*

This state uses a fuzzy controller to keep the robot in the middle of the 2 lines, or 1.5m away if it finds only 1 line and set *L* as the left wheel command and *R* as the right one, continuing to do so until *last_point_distant* is set. To later use, this state sets *last_movement_forward and sense* to 1. If one of the model's last point is negative and farther than 50 cm the robot got to the end of the line and needs to begin turning. For the maneuver, it sets *last_point_distant* and transitions to **Left Turn Begin** state, beginning to rotate on its own axis.

➢ *Backward State*

In a similar way, this state uses a fuzzy controller to keep the robot in the middle of the 2 lines until *first_point_distant* is set. To later use, this state sets *last_movement_backward and sense* to -1. If one of the model's first point is positive and farther than 50 cm the robot got to the end of the line and needs to begin turning. It then sets *first_point_distant* and transitions to **Left Turn Begin** state, beginning to rotate on its own axis.

➢ *Left Turn Begin State*

This state makes the robot turn anticlockwise on its own axis while the angle it makes with the x axis is smaller than π/3.5 or about 50º. When this limit it achieved, *angle_smaller* is reset to 0 and the transition is made to state **Left Turn Mid**.

➢ *Left Turn Mid State*

The next step is to decide whether to move backwards or forwards. This information comes in the *sense* variable, and thus the robot begins to move in that particular direction, for example let's say it should go forward. When moving, the robot stores the intercept of the Right model (the model the robot moves away from) and updates when the intercept gets bigger than 10% of the stored value, doing so to prevent errors in model estimation and tiny variations. When the robot identifies the right intercepts jumps from a big value to around 0.5, it means that the robot is between two rows and needs to merge. Thus, *intercept_changed* is set and the transition goes to **Left Turn Merge**.

➢ *Left Turn Merge State*

Finally, the robot starts rotating clockwise on its own axis while the angle it makes with the x axis is greater than -π/6.0 or about -30. When this limit it achieved, *angle_bigger* is reset to 0 and the transition is made to state **Forward** if the last movement was backward, or **Backward** otherwise.