MRSD Project Course

Team I – AIce

Autonomous Zamboni Convoy

Progress Review 8

Team

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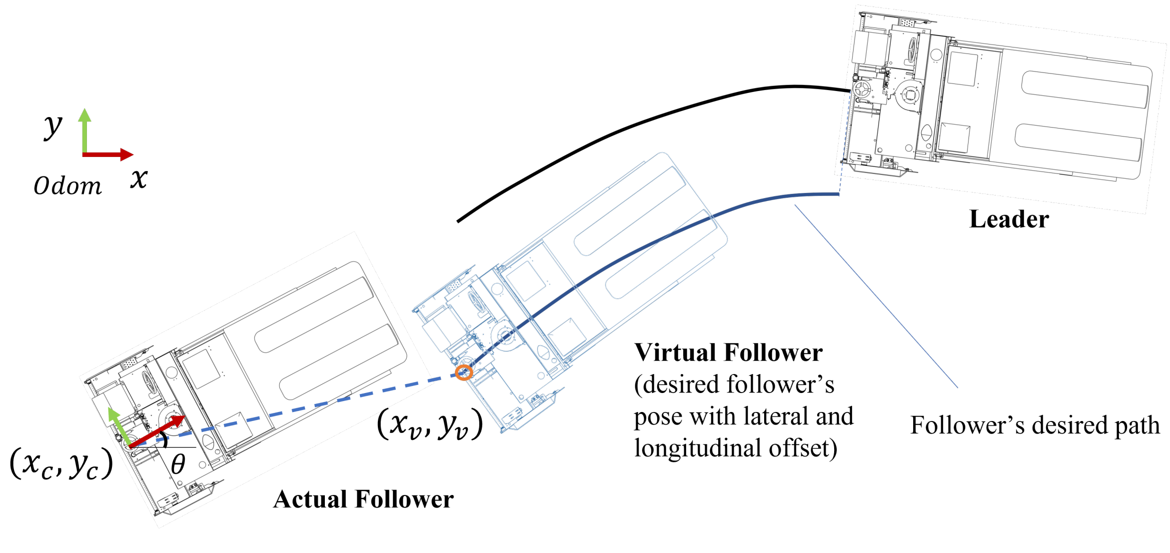
1 Individual Progress

In general, from last progress review, our team shipped the Zamboni to our collaborator Isuzu. And by the coordinating with the AirLab, we gained the access to the ATV vehicle. With the progress in the major logistic part, we are able to really focus on the technology parts and put all the software algorithms into practice.

My major focus is the autonomy stack part. Since we are leveraging the ATV vehicle to test the software algorithms when the Zamboni is under drive-by-wire (DBW) conversion, we need to first integrate the software previously developed for simulation and RC car to the ATV code base.

1.1 Planner

In our previous autonomy software architecture, the leader's path is recovered by adding perception result to the follower's own position. After leader path recovery, we add a lateral offset to the path to get the desired path for the follower. To this end, we can only guarantee that the two vehicles cover different paths with a lateral offset. To keep the longitudinal offset, our previous method is to estimate the leader's velocity using EKF and take the estimated velocity as the target velocity of the follower. However, such open-loop velocity cannot guarantee the constant longitudinal offset. Here, the improvement is made to use a position controller to keep the constant distance.



Error: $e_l = (x_v - x_c)\cos\theta + (y_v - y_c)\sin\theta$

Figure 1: Virtual follower planner.

To determine the target the pose of the follower to track, a virtual follower is proposed. First, the leader's pose is recovered based on the localization and estimation. Then the pose sequence of the leader is recorded so that we can maintain a trajectory of the leader. By taking the integration back the distance it has travelled from its current pose, we can determine the waypoint that corresponds to the virtual follower. As shown in Fig. 1, the arc length of the blue curve is computed as a reflection of the longitudinal offset.

The virtual follower-based feedback-tracking algorithm has the potential to ensure safe tracking, where the virtual follower can maintain the required position with the leader. By tracking the position of virtual follower, safety and required formation between the leader and the follower could be obtained. The error is the current pose and virtual follower is computed as an input into the controller.

1.2 Software integration

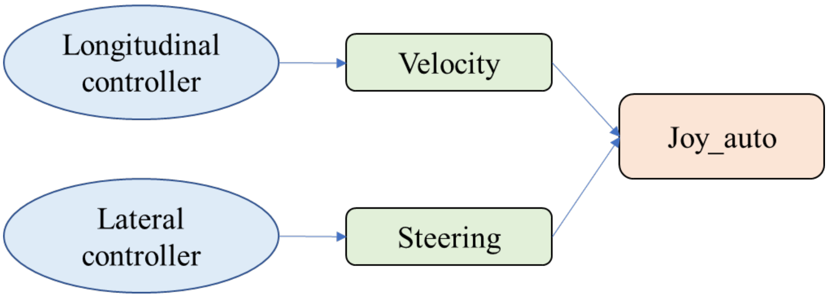


Figure 2: ATV autonomy topics.

I also re-organize the code base for our leader-following autonomy and figured out the interface with the ATV's inbuilt autonomy stack.

To send an autonomous command to the ATV, we have to create the 'fake' joystick topic by which to communicate with the lower level controller of the vehicle. Therefore, we will use the 'fake' joystick topic 'Joy_auto' which takes in the velocity and steering command from the controllers, as shown in Fig. 2.

2 Challenges

One challenge of the planner is how to determine the offset when the leader is taking a turn. When the leader's path is curved, we cannot directly use a leader coordinate transform to determine the virtual follower. So the way I deal with the challenge is to integrate from the leader's current pose back until find the waypoint that make sure the arc length is the desired longitudinal offset.

Another challenge is the controller design. Currently we separate the lateral and longitudinal controller. The lateral controller is based on pure pursuit which takes in a targeting waypoint determined by look ahead distance. However, such waypoint needs us to maintain a local tracking path. And the targeting waypoint is different from the virtual follower determined before. I am planning to combine the lateral and longitudinal controller into a single controller that take care of both offset.

3 Teamwork

Kelvin Shen is in charge of perception and recognition. His progress includes:

- Looked into problems of losing aruco markers by testing realsense given 6-meter longitudinal distance as the performance requirements.
- Tested performance of realsense under different camera settings (infrared stream vs rgb stream, low fps vs high fps).
- Experimented lidar camera calibration using available data online.

- Helped coordinate with AirLab folks

Rathin Shah is in charge of drive-by-wire system the CAN bus. His contribution includes:

- Helped Nick in mounts for Zamboni.
- Throttle Obj Dict creation for zamboni.
- Coordinated shipping of zambini.
- Tested localization stack of atv on ros bag files.

Nick Carcione is in charge of the DBW hardware. His contribution includes:

- Designed mounts for mounting camera onto ATV and camera+lidar onto Zamboni.
- Updated the team's WBS to reflect work to be done this semester.
- Helped Rathin understand CAN interface for Zamboni.
- Helped get the Zamboni loaded and shipped.

Yilin Cai is in charge of the planning for the robot and software integration. His contribution includes:

- Review the papers and compare the leader following controller methods for maintaining the constant offset.
- Re-wrote the trajectory planner for choosing the follower's target pose.
- Helped Jiayi developed the PID longitudinal controller.
- Re-organize the code base for autonomy stack and simulation

Jiayi Qiu is in charge of the leader's estimation and control algorithm development. Her contribution includes:

- Implemented a PID longitudinal controller to maintain the distance between the leader and the follower.
- Wrote the script of publishing steering and velocity commands to ATV.
- Helped Rathin with testing on ros bag files.
- Helped organize the meeting with Isuzu to get DBW updates.

4 Plans

The leader's pose recovered by the localization and perception module has a lot of noise. The estimation and smoothing of the camera observation data is about the be developed to reduced camera noise and yielded relative positional information between the leader and the follower vehicle with high accuracy. In addition, I am planning to test different controller combination in simulation. And then scale up the system to ATV.