Requirements of Maps for Detection

Considered Use Cases:

A. Trajectory Prediction
B. Detect pedestrians in crosswalk
C. Detecting Traffic Light

*NOTE: Text in gray is assumed to be low priority

A. Trajectory prediction

Use Case

Goal in Context: for each tracked object, extract all logically possible trajectory that this object can move to.
Primary Actor: op_motion_predictor
Level: After filtering
Preconditions: current_pose, curr_velocity, HD map topic, and tracked_objects are available. The tracked objects should have orientation.
Success Guarantee: all possible driving trajectory from map is extracted.
Map Access Frequency/Trigger: depends on sensing frequency 10~20 hz
Main Success Scenario:

1. Receive Map Data
2. Build road network map locally for planning
3. Extract all the possible trajectories that this waypoint lead to.

Requirements:

1. Map module should provide enough information to predict trajectory of detected vehicle
    a. Map module should provide **shapes of roads** to filter out uninterested objects
    b. Map module should provide **closest lane** when the pose of a detected vehicle is given
    c. Map module should provide **lane graphs** which allows query for **reachable lanes** to a given lane
        i. successive lanes
        ii. preceding lanes
        iii. lane changeable lanes
    d. Map module should provide **reference trajectory(centerline)** when given a sequence of lanes
    e. Map module should provide **traffic rules** associated to given lane as traffic rules might affect trajectory of predicted objects (e.g. stop lines, yield, right-of-way)
2. Map module should provide enough information to predict trajectory of bikes
    a. offset from centerline
3. Map module should provide enough information to predict trajectory of pedestrian
    a. graphs for sidewalks and crosswalks
4. Map module is able to provide above information at same frequency with detection frequency.
    a. LiDAR 20Hz, Camera 30Hz
    b. optimized searching for querying objects (kdtree?)
5. Map module is able to provide above information at enough distance
    a. At least 100m assuming that lidars can detect up to 100m
        NOTES: This could depend on the velocity of objects. e.g. if a vehicle is driving at 20km/h (5.5m/s) and if you want to know the collision before 10 seconds, then only 55m range is required.

B. Detecting pedestrians in crosswalks:

Use Case:

Goal in Context: Detect pedestrians passing a crosswalk and vehicle stops before hitting pedestrian

Primary Actor: vehicle, pedestrian

Level: subfunction

Preconditions: HD map topic, waypoint topic, and sensor inputs(LIDAR and camera) are available

Success Guarantee: Vehicle does not run into pedestrian in crosswalk(i.e. waypoint has appropriate velocity)

Map Access Frequency/Trigger: 10 hz

Main Success Scenario:

1. Extract crosswalk that intersects with current planned path
2. Apply perception algorithm to detect pedestrians around vehicle
3. If detected pedestrian is near or within the crosswalk, change velocity in planned path so that vehicle stops before entering crosswalk

---

Requirements

1. Map module provides enough information to detect pedestrians in crosswalk
    b. Map module is able to provide a **sequence of lanes for a planned path**
        i. up to 50m?
    c. Map module is able to provide **crosswalks associated to a given lane**
        i. Map should be able to provide the **shape of crosswalks** for inside/outside judgement for pedestrians
        ii. Map should be able to provide **stop position** when there is pedestrian on crosswalk
2. Map is able to provide above information at same frequency with detection frequency.
    a. LiDAR 20Hz, Camera 30Hz
    b. This could be much lower as long as it can retrieve information ahead of time since the position of traffic light does not change.

C. Detecting Traffic Lights

Use Case:

Goal in Context: Detect traffic light using position information provided by HD map, recognize its color, and stop in appropriate location if it is red Level: subfunction
Primary Actor: Vehicle, HD Map Preconditions: HD map containing traffic light and associated stop line information, camera position relative to map, current path information known
Minimal Guarantee: If expected occluded/traffic light not detected - issue warning, reduce speed?
Success Guarantee: Vehicle stops at stop line of traffic lights when they are red, proceeds along path otherwise
Map Access Frequency/Trigger: 50Hz Main
Success Scenario:

1. From current camera position and current path, identify all applicable HD traffic light elements
2. Determine if individual traffic lights are visible in camera field of view
3. Project 3D traffic light position into camera plane
4. Generate a Region of Interest for each traffic light element in image pixel coordinates
5. Apply traffic light detection algorithm to image with ROI information
6. Use traffic light recognition result to decide vehicle behaviour, either:
    a. Stop at traffic light
    b. Proceed through traffic light
7. According to chosen behaviour and with reference to relevant HD Map stop line information, modify vehicle motion plan
8. Execute vehicle motion plan

Requirements:

1. Map Module provides enough information for detecting traffic lights
    a. Map should be able to provide a **sequence of lanes of a planned path**
    b. Map should be able to provide **position and size of traffic lights** associated to a given lane
2. Map is able to provide above information at same frequency with detection frequency.
    a. Camera 30Hz

Comments & Questions:

- needs good association between objects and lanes
- Use case not concrete:
    - Velocity of the vehicle?
    - How large is parking area
        - Map could be small enough and might not need any trimming
        - Can we really ignore driving at public roads?
        - Inside building? 2nd floor?
- How much availability should Map module provide?
    - Should it just provide position and shapes of objects, or should it have more usefule APIs e.g. geometrical calculations, querying by position,
- Other things that must be considered memory usage, cpu usage
    - This cannot be determined unless reference ecu is available
    - Is it possible to use shared memory?
- Should the road network created at loading or should it be saved as physical file format?