Object Tracking

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1 Introduction

1.1 Single Object Tracking

Single object tracking is essentially a filtering problem. We are dealing with sequential processing of a noisy sensor measurements in order to determine the state of the object.

> *Remark* 1.1. When we say state we actually mean the position of the object together with properties that describe its motion e.g. speed and direction

The filtering problem is not so easy to solve since the state of the object is neither fully not directly observed.

> **Definition 1.1. Multiple Object Tracking (MOT)**
>
> Multiple Object Tracking is defined as the sequentioal processing of noisy sensor measurements in order to determine the number of dynamic objects in each dynamic state of the object.

Typically MOT is based on sensor detections. common sensors in MOT are

- Cameras
- Radars
- LiDARs

In addition, the sensor data serves as input to a detector. The block diagram in Figure 1 illustrates the concept.
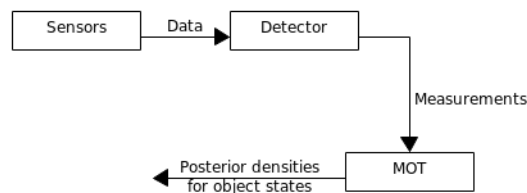
Fig. 1: MOT block diagram.

1.2 Challenges in MOT

Despite the abudance of the different MOT methodologies, problems do arise. In this section we will outline some of the problems and challenges that typically
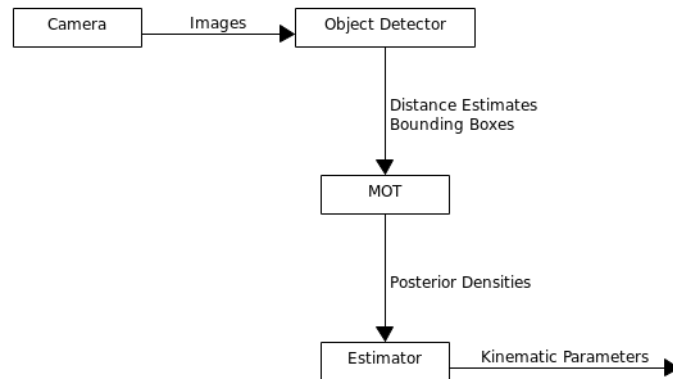
Fig. 2: Camera block diagram.

an engineer, or whoever is atsked with developing a MOT pipeline whatsoever, has to face.

Let's consider again autonomous vehicle driving along a road. Assumme that the vehicle is equipped with a sensor. The first problem one is faced with, is the unknown number of objects in the sensor's FoV. In addition to this, we typically do not know the state of these objects; where they are located, where they are going etc. Arguably, however, it may be possible to have a reasonable estimate of these state. Furthermore, the tracked objects may move around with their own speed and orientation. This results in some objects leaving the FoV of the sensor whilst others, not tracted previously, enter the sensor's FoV.

Remark 1.2. In the relevant literature of target tracking, object appearance is sometimes called bilrth, while object disappearance is often called death.

Another problem frequently encountered in practice is that some objects may occlude others. Finally, sensors are not perfrect. Therefore, one has to deal with the following two types of errors

- Missed detections
- False detections

1.3 Questions

1. Which property or properties hold(s) for the track-before-detect method?

2. Which property or properties hold(s) for the point object tracking method?

3. Which property or properties hold(s) for the extended object tracking method?

4. Which property or properties hold(s) for the group object tracking method?

5. Which property or properties hold(s) for the tracking with multi-path propagation method?

6. Which property or properties hold(s) for the tracking with unresolved measurements method?

7. Which of the following challenges are added when considering Multiple Object?

   (a) An unknown and time-varying number of objects

   (b) The state of each object is unknown and changes over time.

   (c) The object states cannot be fully observed directly, have to be inferred from partial measurements.

   (d) The measurements are corrupted by noise, and are susceptible to missed detections and false detections.

   (e) An unknown correspondence between multi-objects and their corresponding object-originated measurements.

1.4   Assignements

1.5 Answers

1. Which property or properties hold(s) for the track-before-detect method

   Answer:

   (a) The approach can be used in tracking scenario with very low Signal-to-Noise-Ratio

   (b) Doesn't use a detector, input raw sensor data into MOT.

2. Which property or properties hold(s) for the point object tracking method?

   Answer:

   (a) At most one detection per object per time scan.

   (b) Possibly provide object extent estimate

3. Which property or properties hold(s) for the extended object tracking method?

   Answer:

   (a) Possibly provide object extent estimate.

   (b) Possibly multiple measurements per object

4. Which property or properties hold(s) for the group object tracking method?

   Answer:

   (a) Possibly provide object extent estimate. correct .

   (b) Possibly multiple measurements per object

   (c) The tracked object consists of smaller "sub-objects" that move in common formation.

5. Which property or properties hold(s) for the tracking with multi-path propagation method?

   Answer:

   (a) Measurements resulted from multiple propagation paths.

   (b) Possibly multiple measurements per object.

6. Which property or properties hold(s) for the tracking with unresolved measurements method?

   Answer:

   (a) A group of close objects that collectively result in a single measurement

7. Which of the following challenges are added when considering Multiple Object?

   Answer:

   Options 1 and 5 are correct. The unknown correspondence between multi-objects and their corresponding object-originated measurements is also known as data association problem. This problem adds additional challenges in n object tracking and multiple object tracking. Further, in multiple object tracking, the number of objects is unknown and may be time-varying, which adds additional challenge compared to n object tracking.

References

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[2] Karl Granstrom, Markus Baum, Stephan Reuter, *Extended Object Tracking:Introduction, Overview and Applications* Available at `https://arxiv.org/pdf/1604.00970.pdf`, last accessed 13/04/2019.

[3] `https://en.wikipedia.org/wiki/Multipath_propagation`