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Robotics Research Center

University of Science and Technology of China

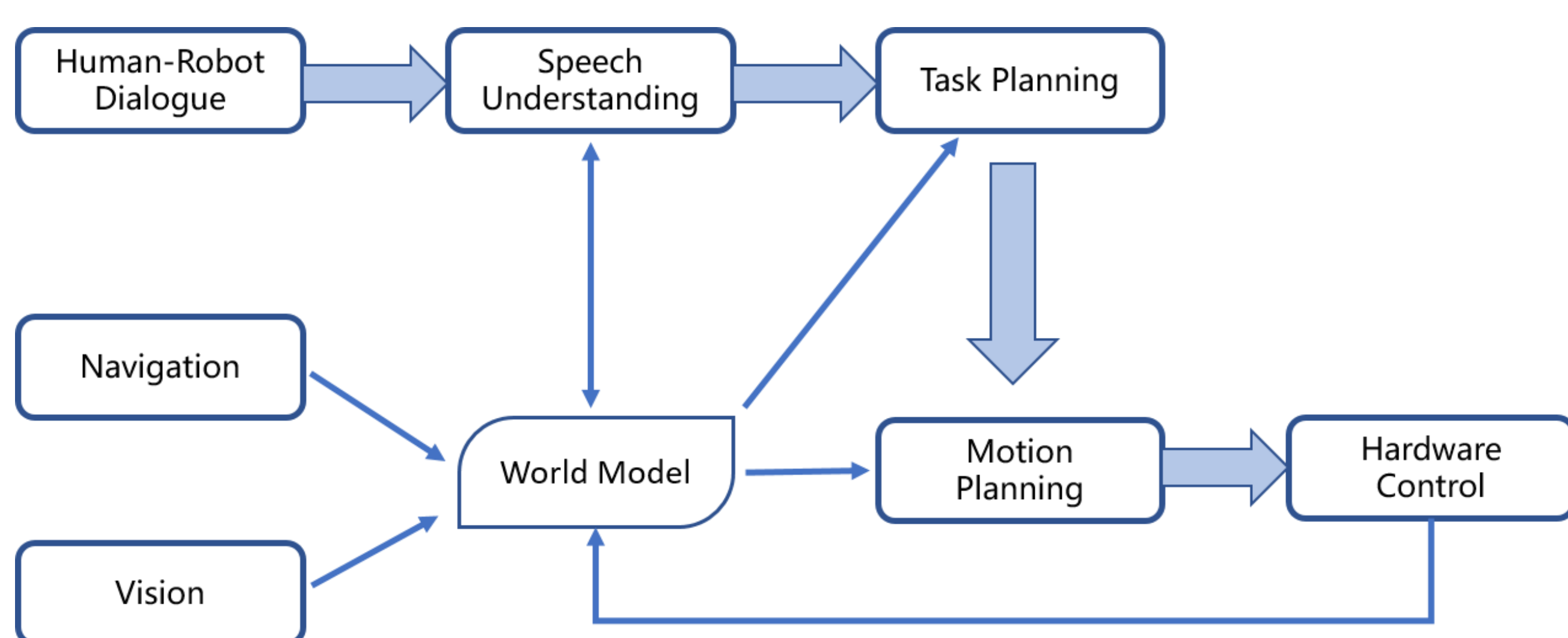
Guangda Chen, Guowei Cui, Zhihan Liao, Nan Lin, Wei Shuai and Xiaoping Chen

Introduction

KeJia is a long-term project aiming to advance the service robots with integrated intelligence. The techniques of NLP, AI, and Robotics have been developed and integrated for the general-purpose services in the real environment. Our recent efforts on fast object recognition, 3D mapping via RGB-D, classification recognition, and multi-robot task planning have made **KeJia** be competent to serve in a dynamic world.

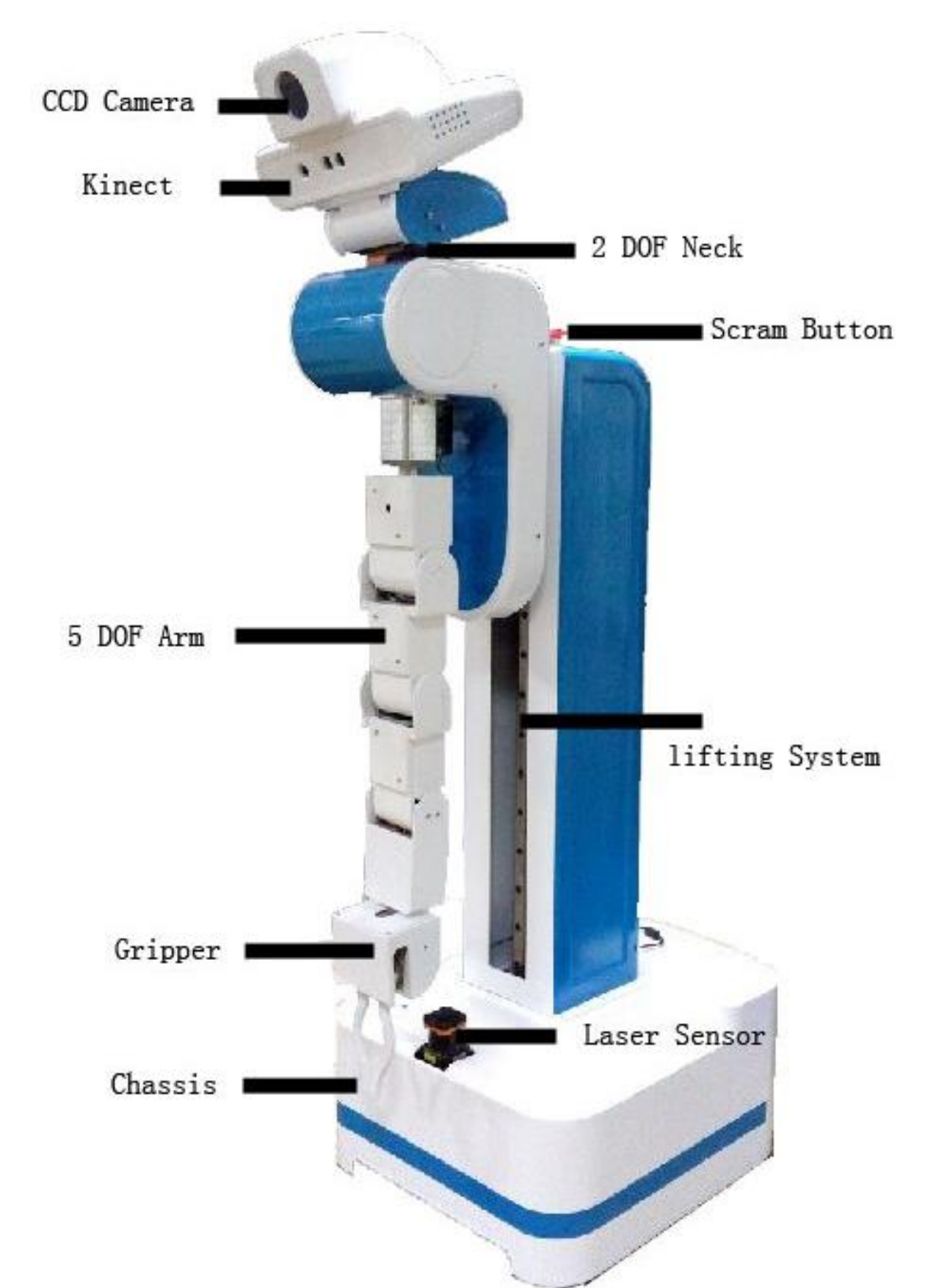
System Overview

Architecture



Hardware

Base	Differential wheel
Manipulators	5 DOF arm
Neck	2 DOF neck
Head	PointGrey HD Camera Kinect for Xbox 360
Laser	Hokuyo UTM-30LX
Computing	Thinkpad T460p Nvidia TX2
Other	Sound Localization Modules

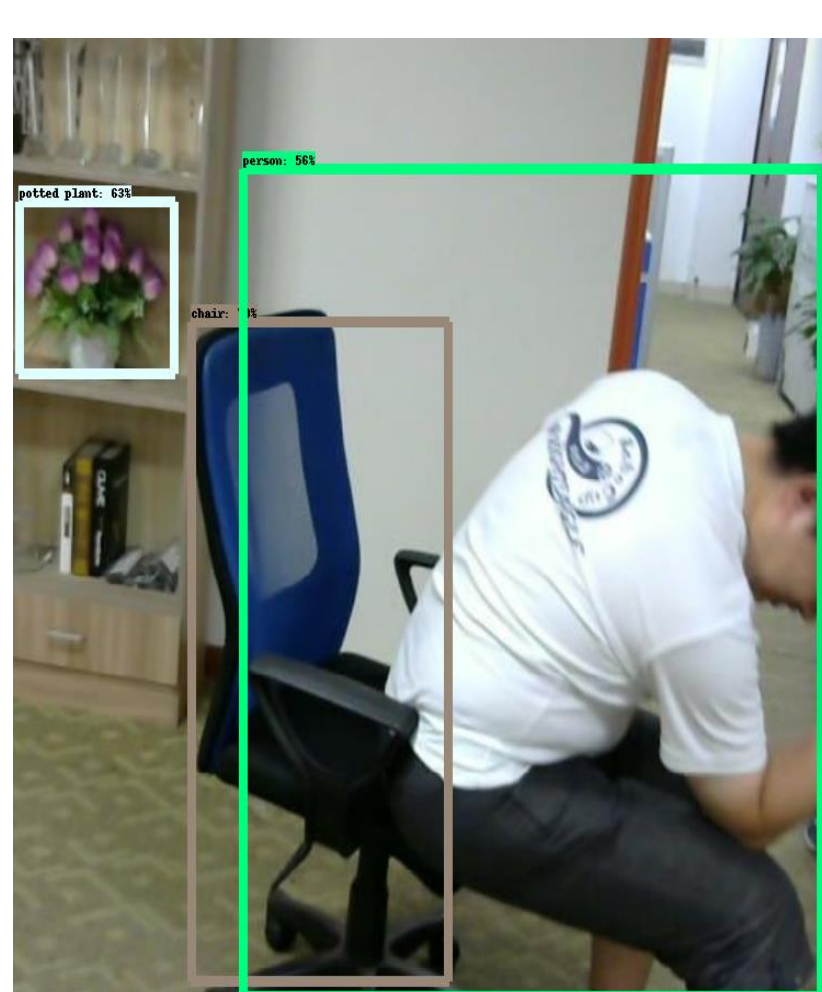


Perception

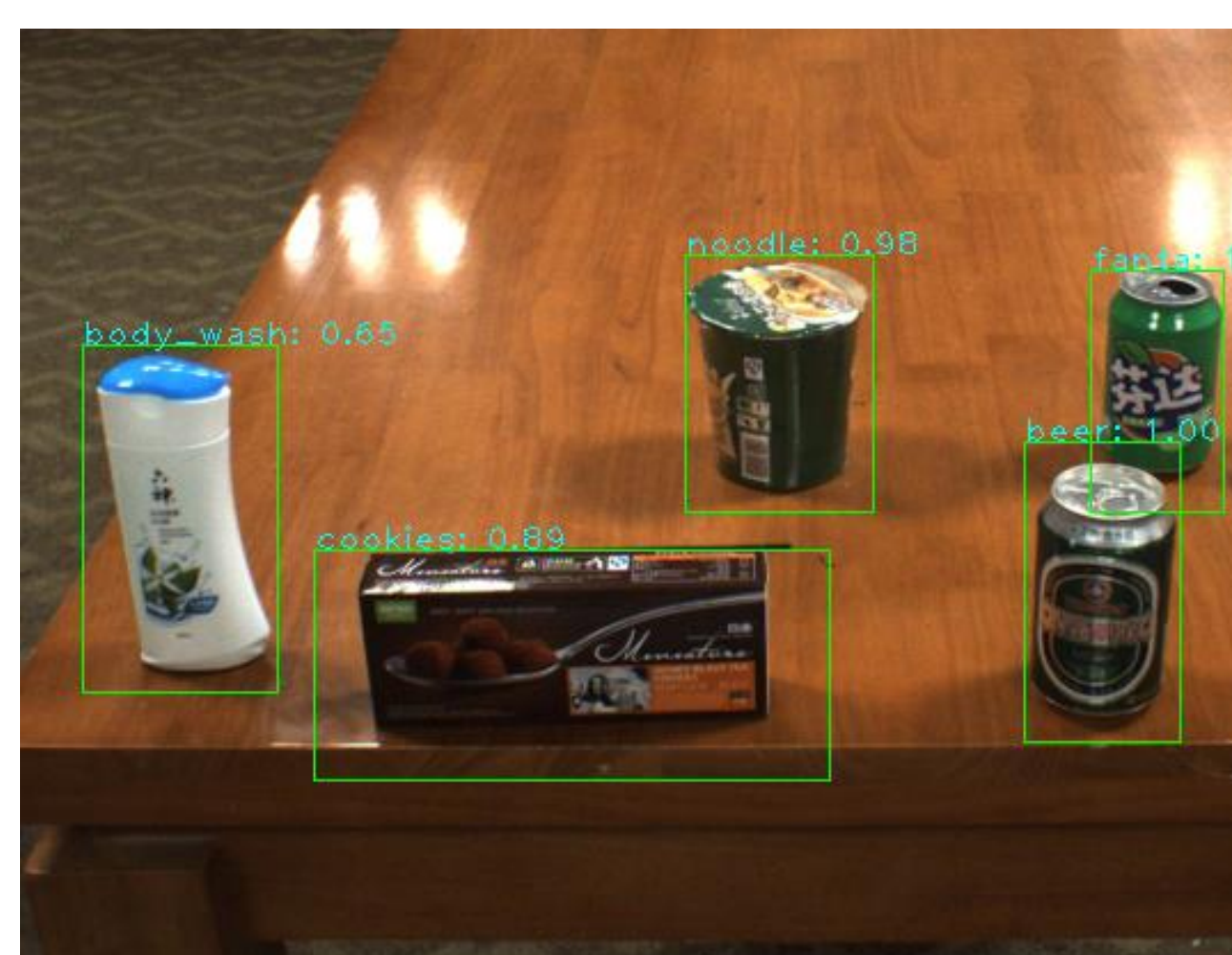
Object Detection

- Single Shot MultiBox Detector
- Proposal + Classification
- Achieves 80% mAP at 10 FPS on a GTX1080Ti

Detection results

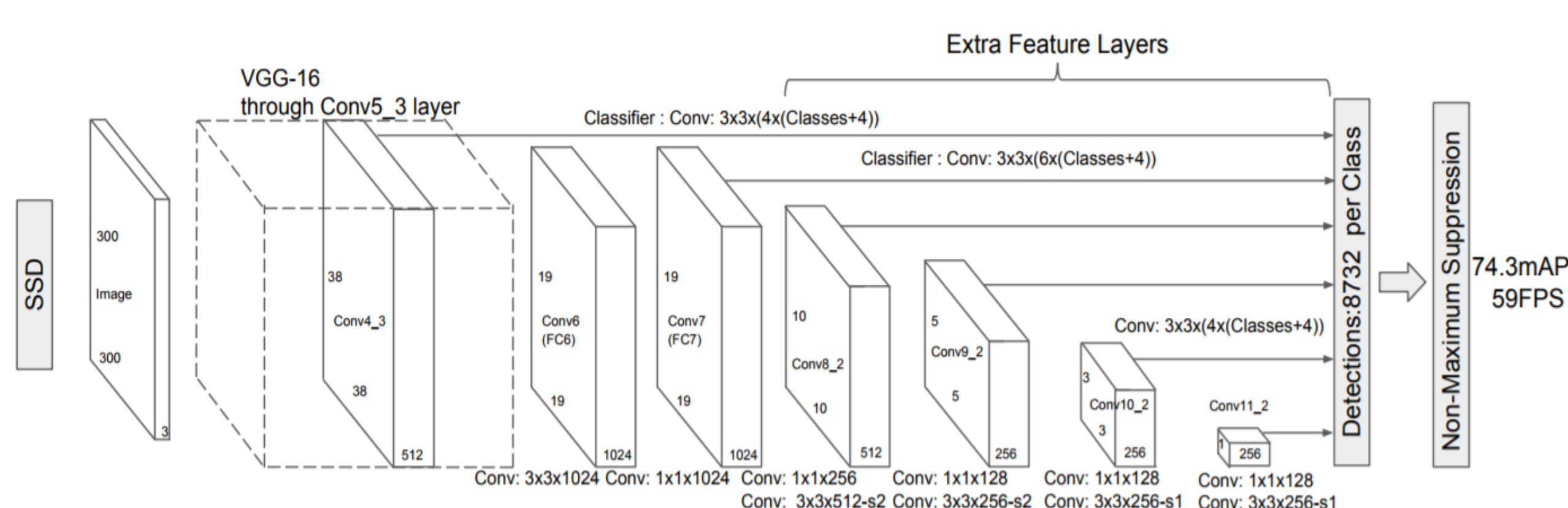


(a) a pretrained SSD from MobileNet



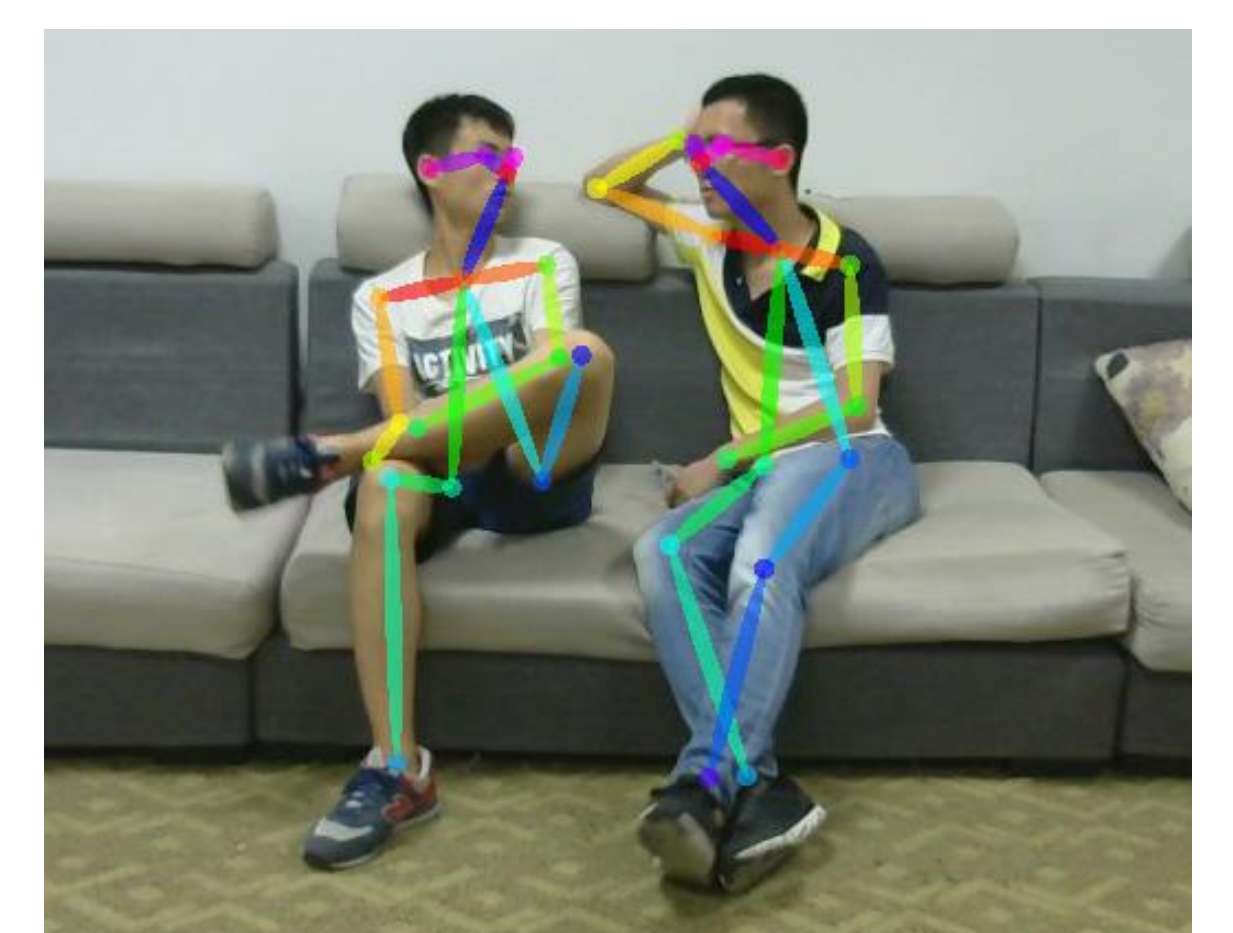
(b) a finetuned SSD model

Structure of SSD



Human Detection

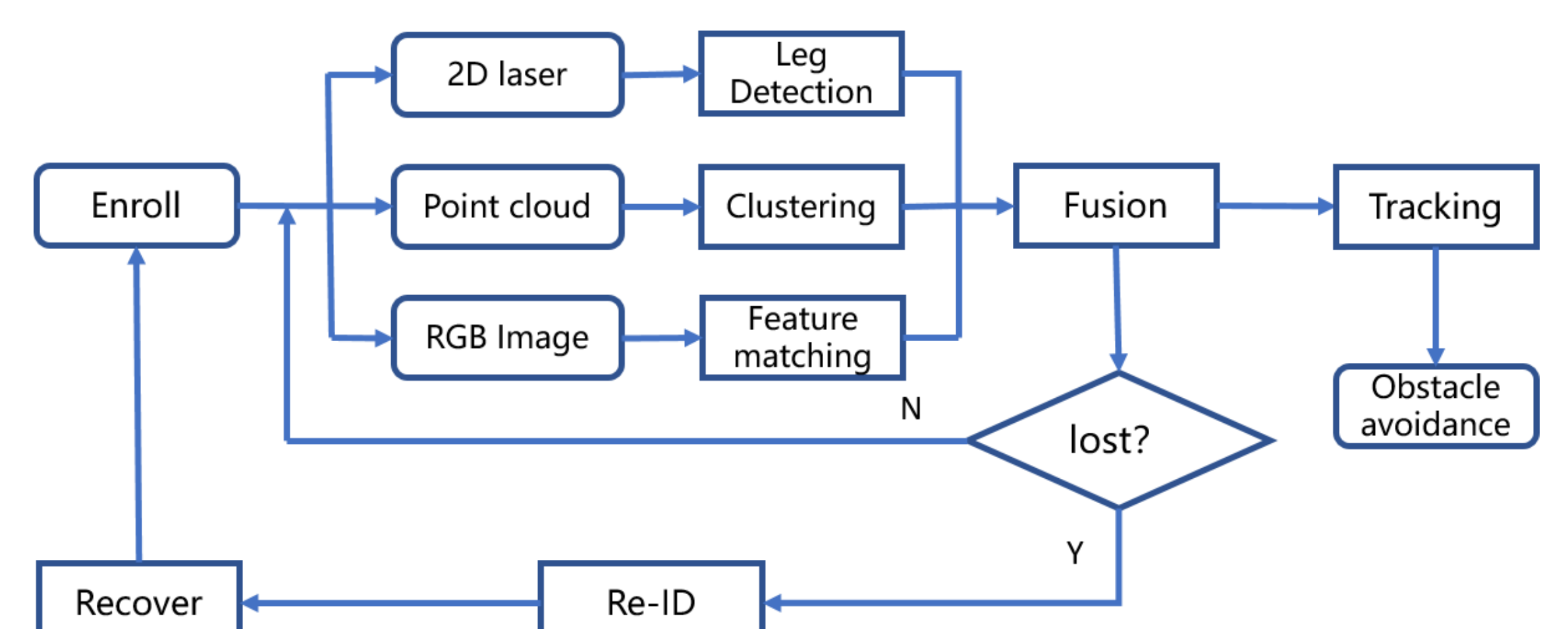
- **Human Pose Estimation**
 - OpenPose library
 - 18 keypoints detection
 - Detect multiple persons from single image in real time



- **Human Face Recognition**
 - face_recognition library



- **Human Tracking**





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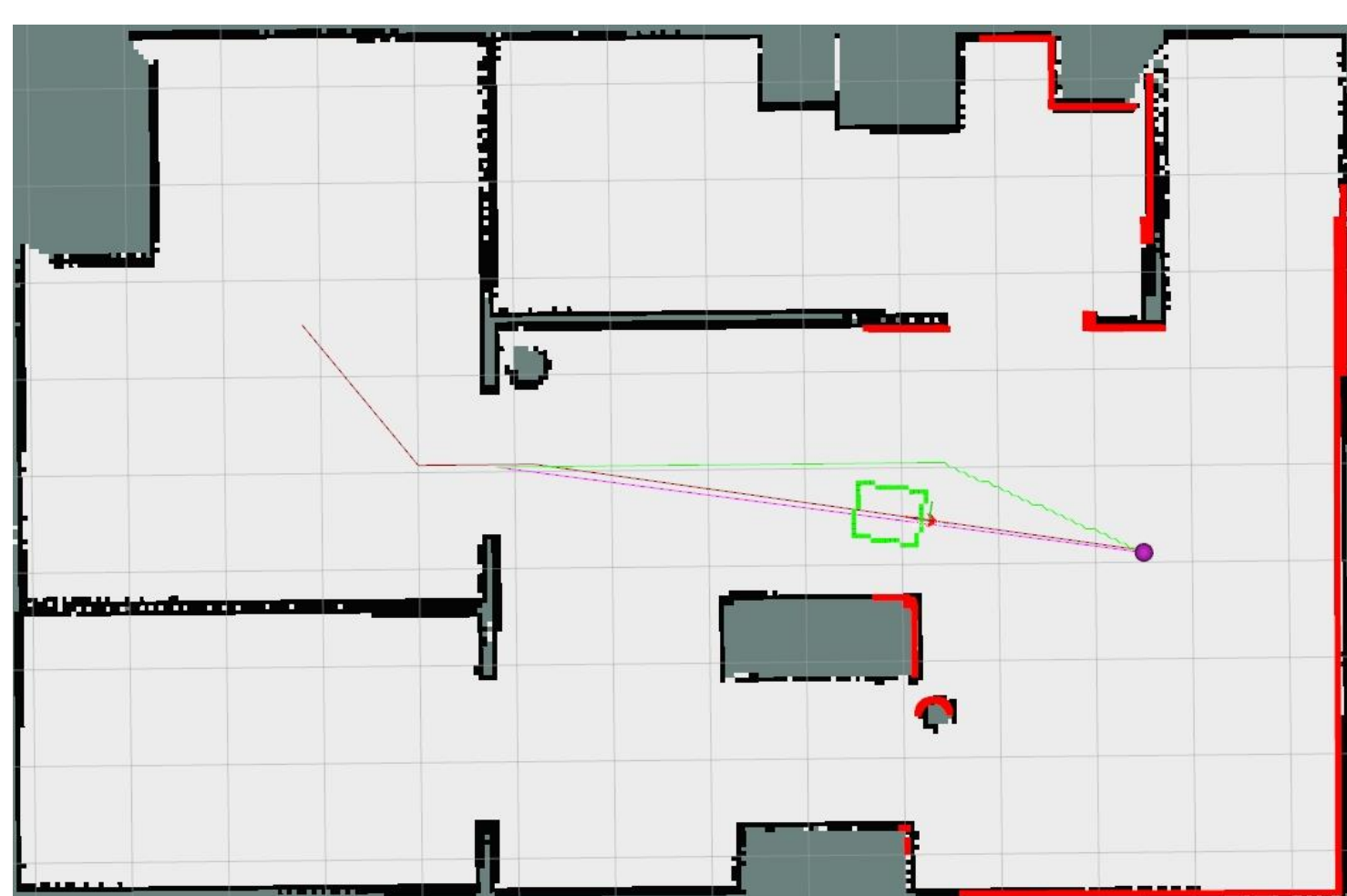
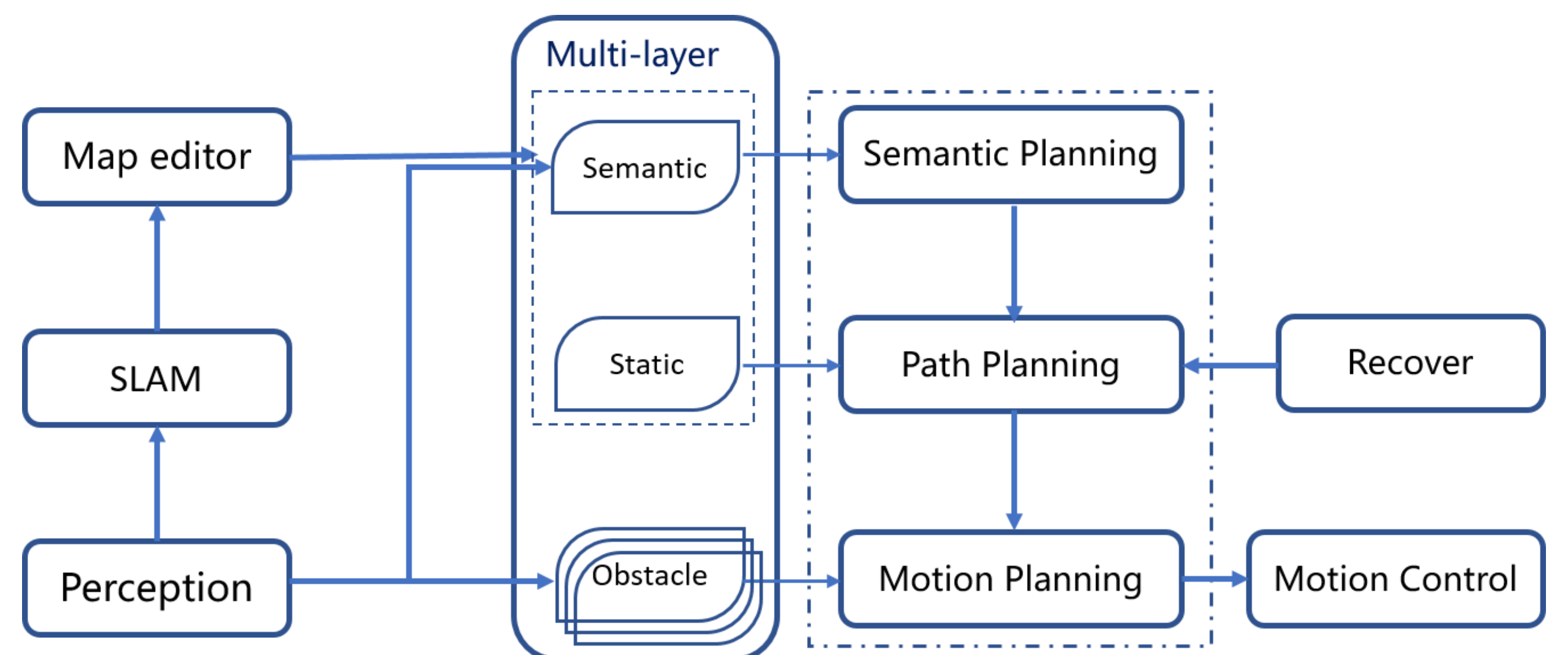
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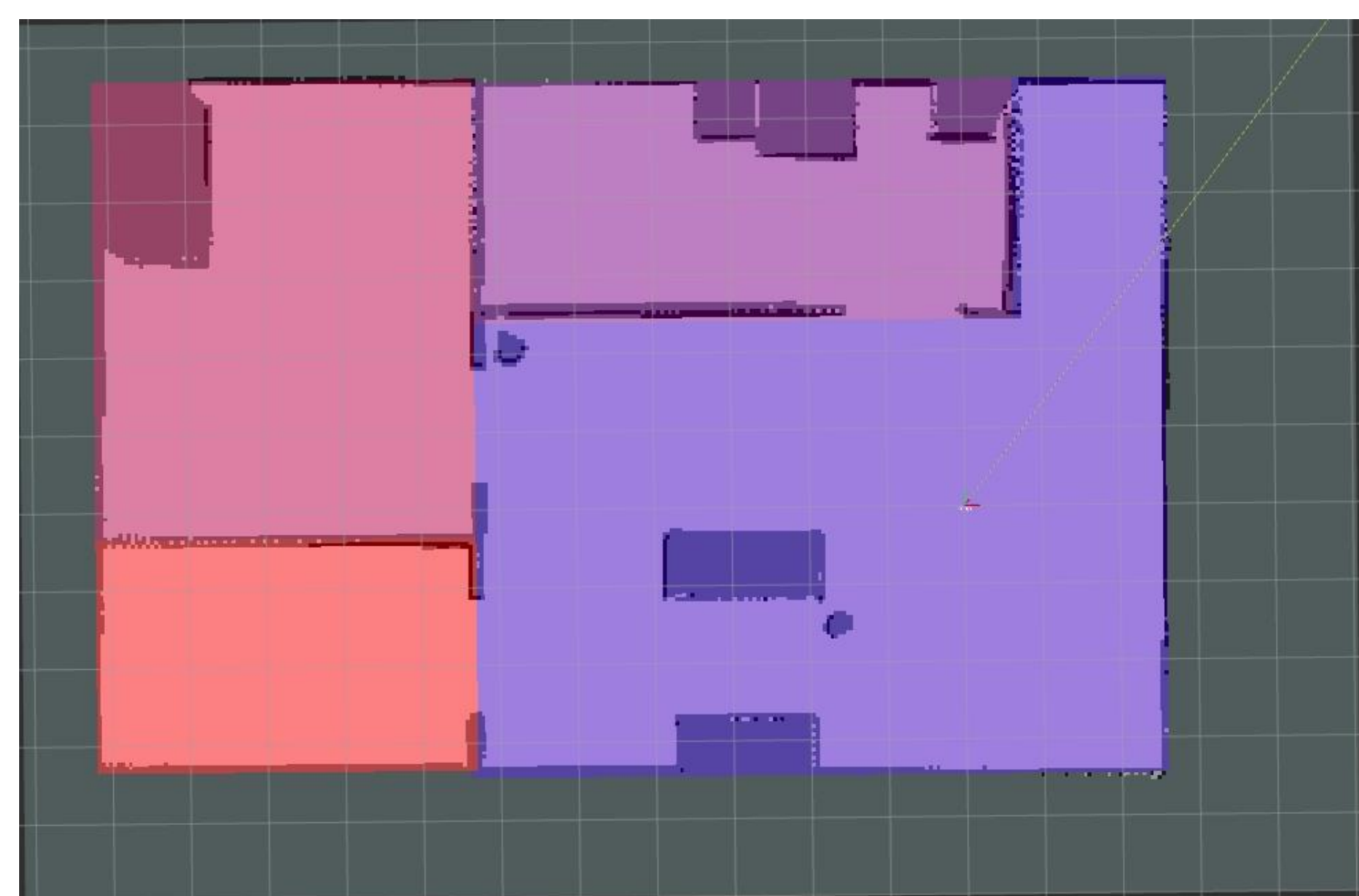
Navigation

➤ Kejia Navigation

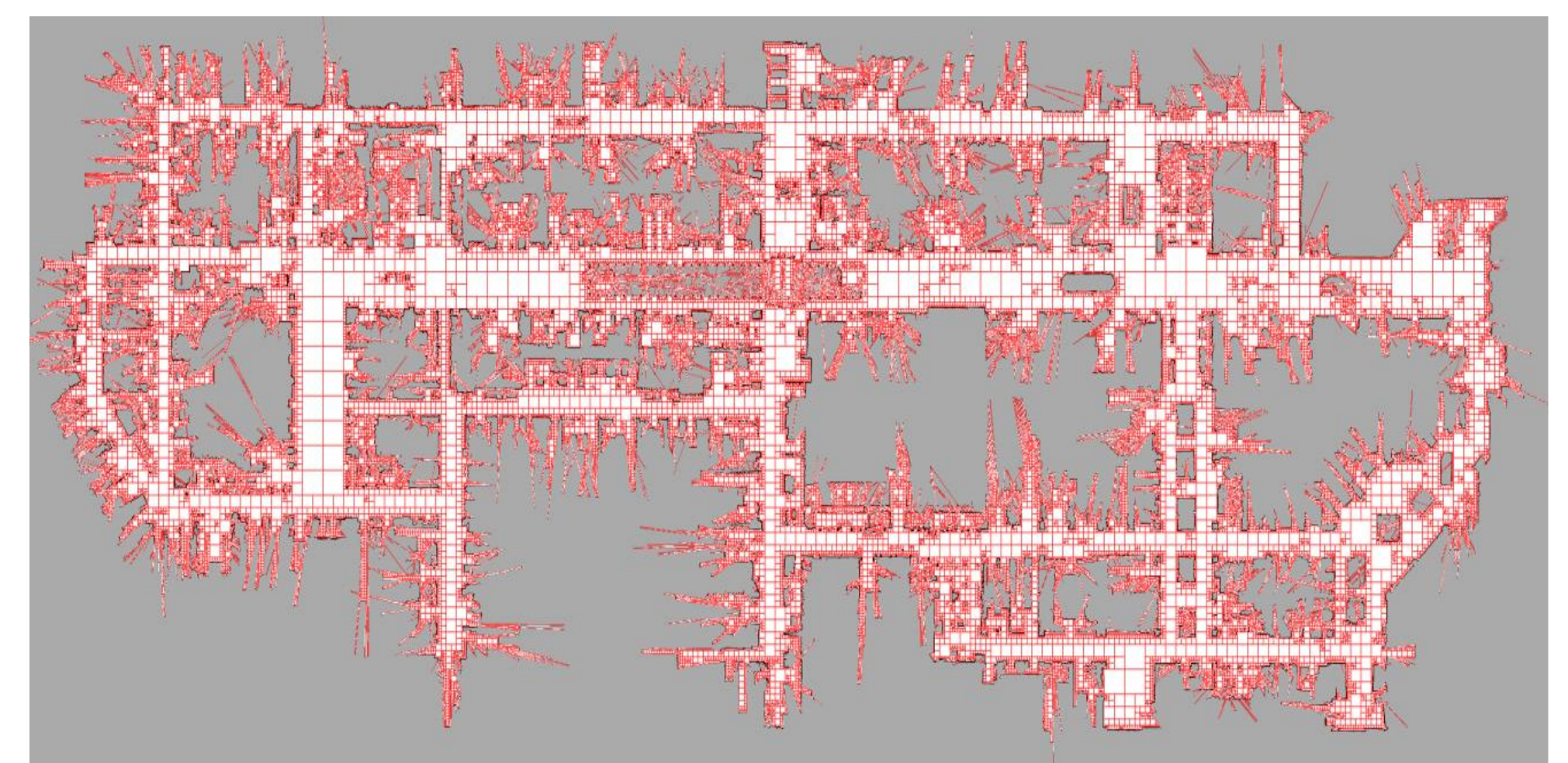
- SLAM : Gmapping
- Multi-layer map with semantic and topological map
- High level semantic navigation
- Path Planner : A*
- Local Planner : VFH*
- Effective Quadtree Representation for Mapping of Large Environments



(a) Kejia Navigation



(b) Semantic Map

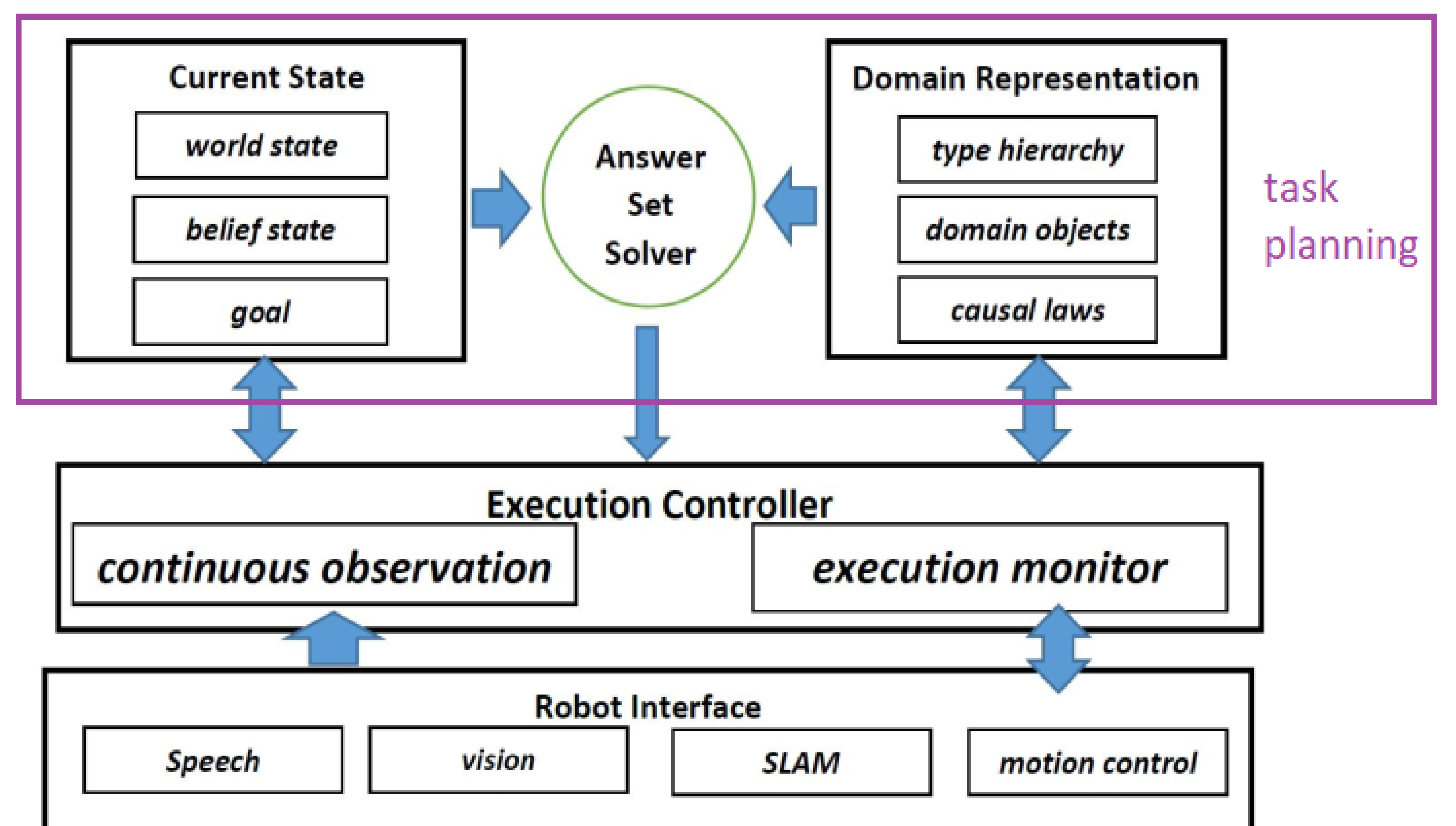


(c) Quadtree Map (237m*100m, 0.05m)

Task Planning

➤ General Purpose Service Robot

- Based on answer set programming
- Acquire and interpret interested contingent information and adapt to changing environment in real time
- Continuous observation constantly receives inputs from robot interface and grounds sensing inputs into symbols and updates current state
- An answer set solver to perform temporal projection reasoning, and sets replan flag if validation fails



Reference and Publications

- [1] Chen, Yingfeng, et al. "Robots serve humans in public places—KeJia robot as a shopping assistant." *International Journal of Advanced Robotic Systems* 14.3 (2017).
- [2] Xiaoping Chen, Jianmin Ji, Zhiqiang Sui, and Jiongkun Xie. Handling Open Knowledge for Service Robots. In: *Proceedings of the 23rd International Joint Conference on Artificial Intelligence (IJCAI-13)*, August 2013.
- [3] Zhao, Zhe, and Xiaoping Chen. "Building 3D semantic maps for mobile robots using RGB-D camera." *Intelligent Service Robotics* 9.4 (2016): 297-309.
- [4] Zhe Cao and Tomas Simon and Shih-En Wei and Yaser Sheikh. Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields. CVPR-2017.
- [5] Liu Wei, Anguelov Dragomir, Erhan Dumitru, Szegedy Christian, Reed Scott, Fu Cheng-Yang and Berg Alexander C.. {SSD}:Single Shot MultiBox Detector. ECCV-2016.