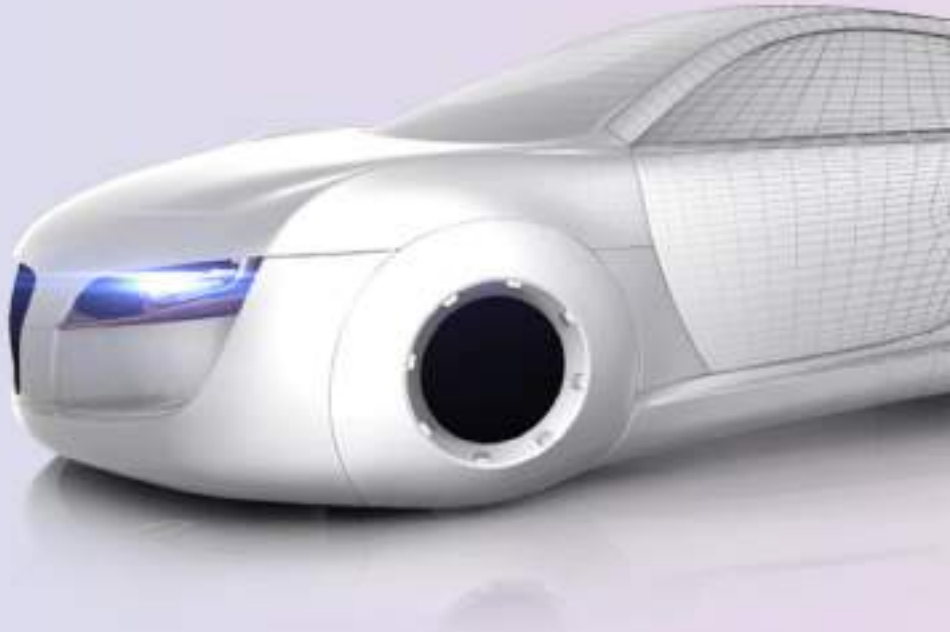
DUBAI WORLD CONGRESS
FOR SELF-DRIVING TRANSPORT
OCT | 2019

Autonomous Robot Guide based on the Loomo Mini Personal Transporter



Dr. Michel Pasquier
Associate Professor
American University of Sharjah

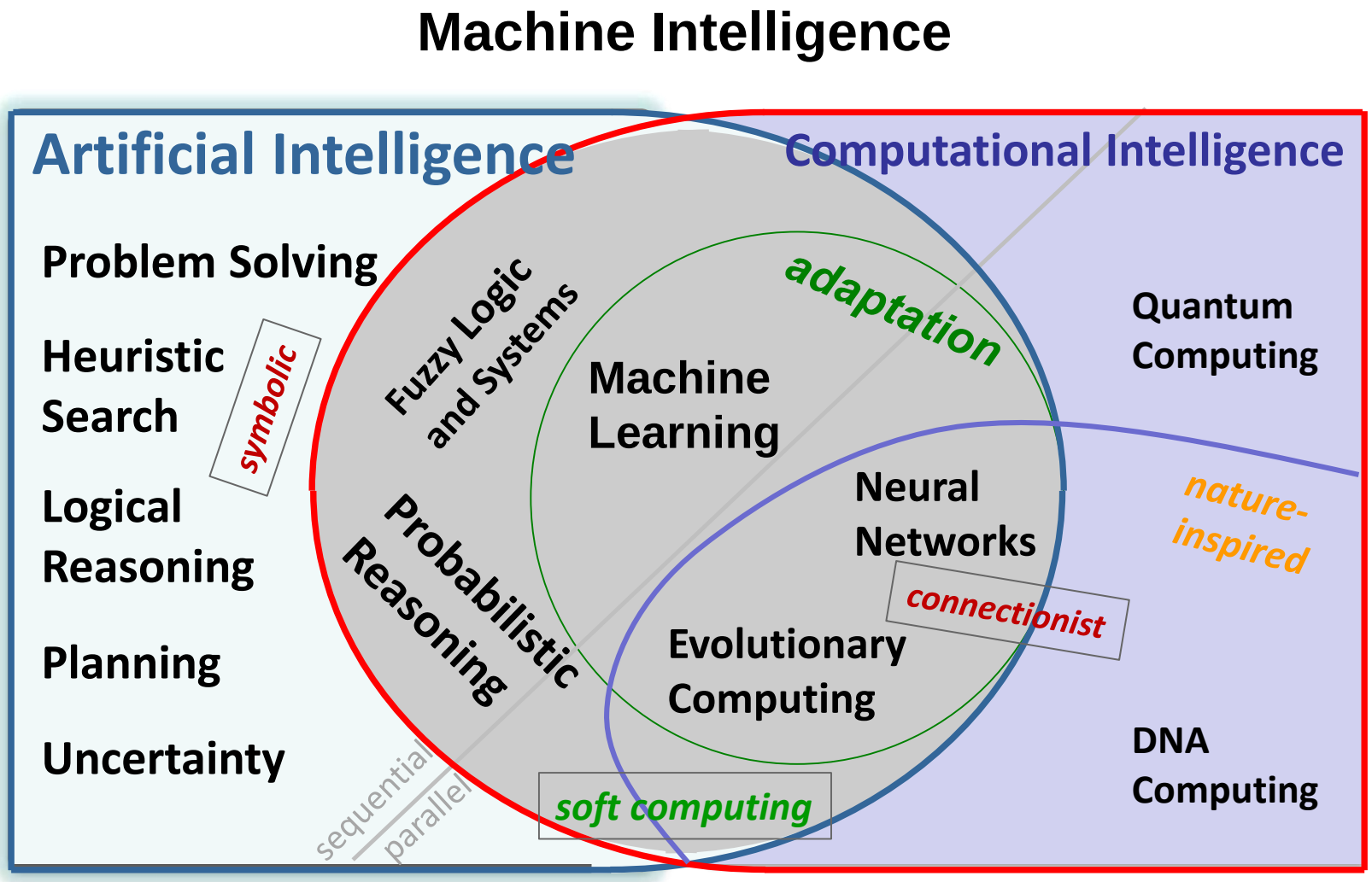
www.sdcongress.com

Complex Adaptive Systems

- *Technological progress renders our environment ever more complex and more incomprehensible.*
  → multi-agents, distributed, highly dynamic, unpredictable
- *"AI is about making machines more fathomable and more under the control of human beings, not less."* (D. Michie)
  → need **automated solutions** that remain **simple to us**
- *"AI is the science of making machines do tasks that humans can do."* (J.F. Allen)
  → require **natural interaction** and **human-like cognition**
- *"It may be that we cannot program intelligent robots, but we can cause them to evolve"* (R. Rucker)
  → **adaptation** and **learning**

Information Classification: General

AI and Learning



Machine Vision – Natural Language Processing – Robotics and Control

Information Classification: General

Cognitive Robotics

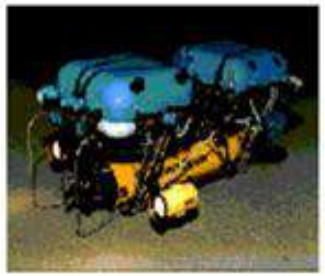
Entertainment
- Avata
- Robot soccer
- I-Robo
- Aibo

Human Aide
- Secretary
- Fault monitoring

Automation
- Autonomous Driving
- Home Automation

Industrial
- Mining Machinery

Exploration
- Rover Sojourner
- Bathy-scaphe



Information Classification: General

Automating Transportation Systems

Information Classification: General

Intelligent Transportation Systems

- **Motivation**
  - **Human errors**: primary cause of traffic accidents e.g., lack of driver attention
  - **In-car technologies**: needed to provide guidance, monitoring, safety
  - **Source of inspiration:** human skill learning
- **Intelligent Cars**
  - **Safety**: minimize road accidents and injuries
  - **Efficiency**: improve traffic network usage
  - **Reliability**: boost performance, predict faults
  - **Flexibility**: adapt to various drivers / users
  - **Expediency**: assist via intelligent interfaces

Information Classification: General

Transportation in the Future

Cycling alternatives

CyCab (INRIA)

ITS

AutoLib

PRT

Information Classification: General

Loomo Personal Assistant and Transporter

Information Classification: General

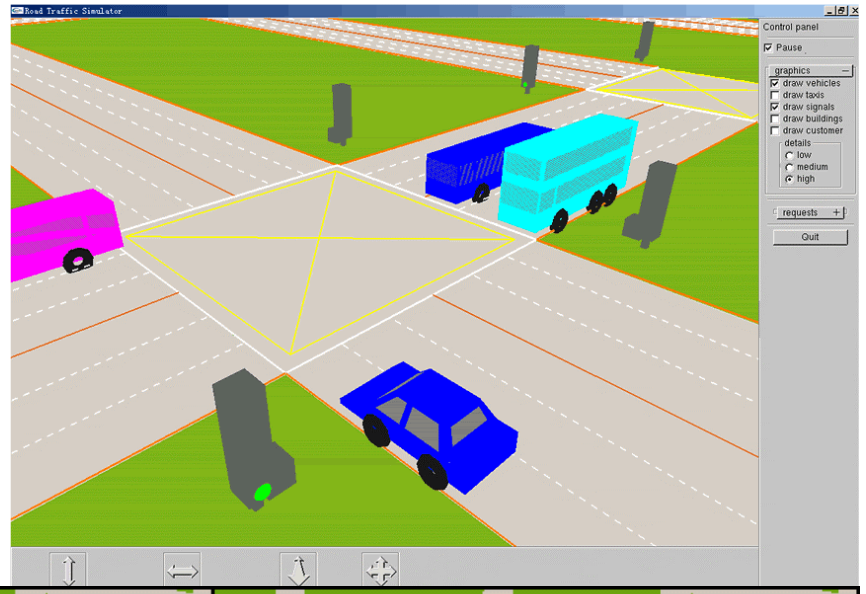
Research Areas

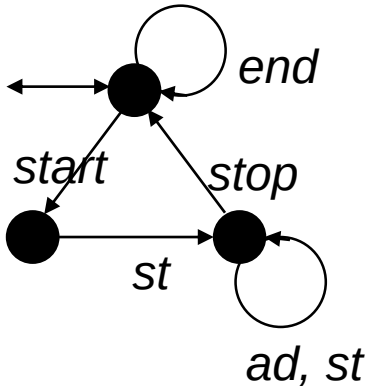
- Fleet management
- Traffic forecasting
- Vehicle navigation
- Vehicle control
- Sensing and data fusion
- Environment modeling
- Human-vehicle interaction

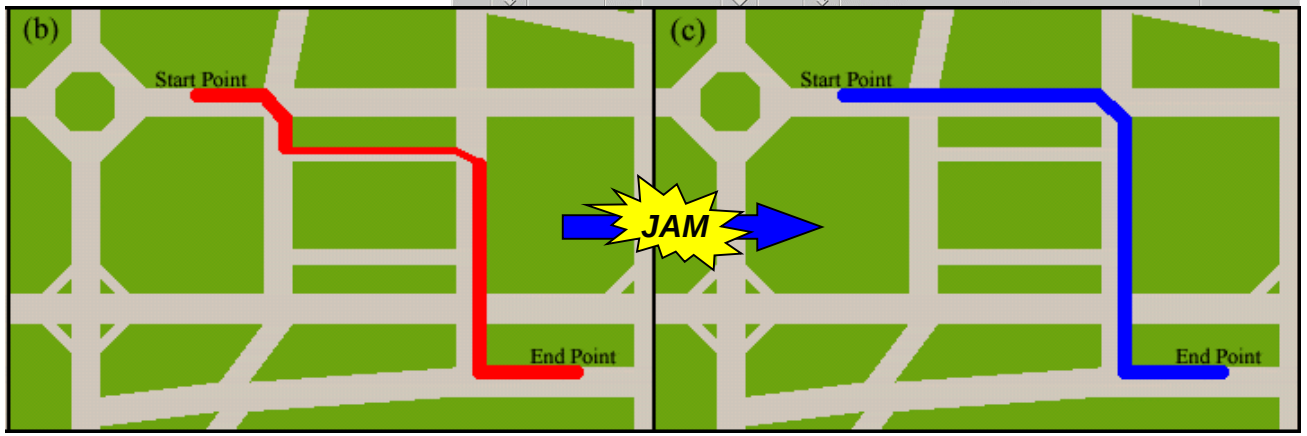
Information Classification: General

Intelligent Fleet Management and Routing

- **Distributed Planning**
  - Blackboard/agent architecture
- **Dynamic Vehicle Routing**
  - ACO-GA, D*, simulator/FPGA
- **Supervisory Control**
  - Controlled automata



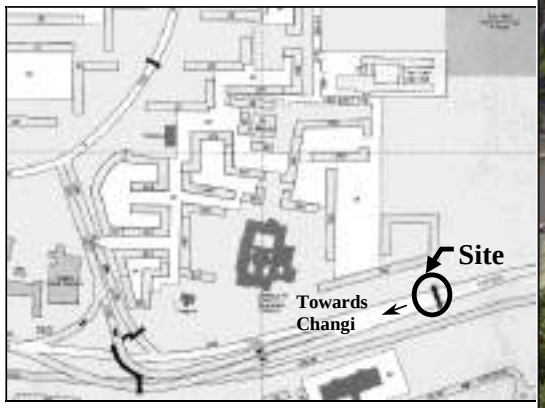


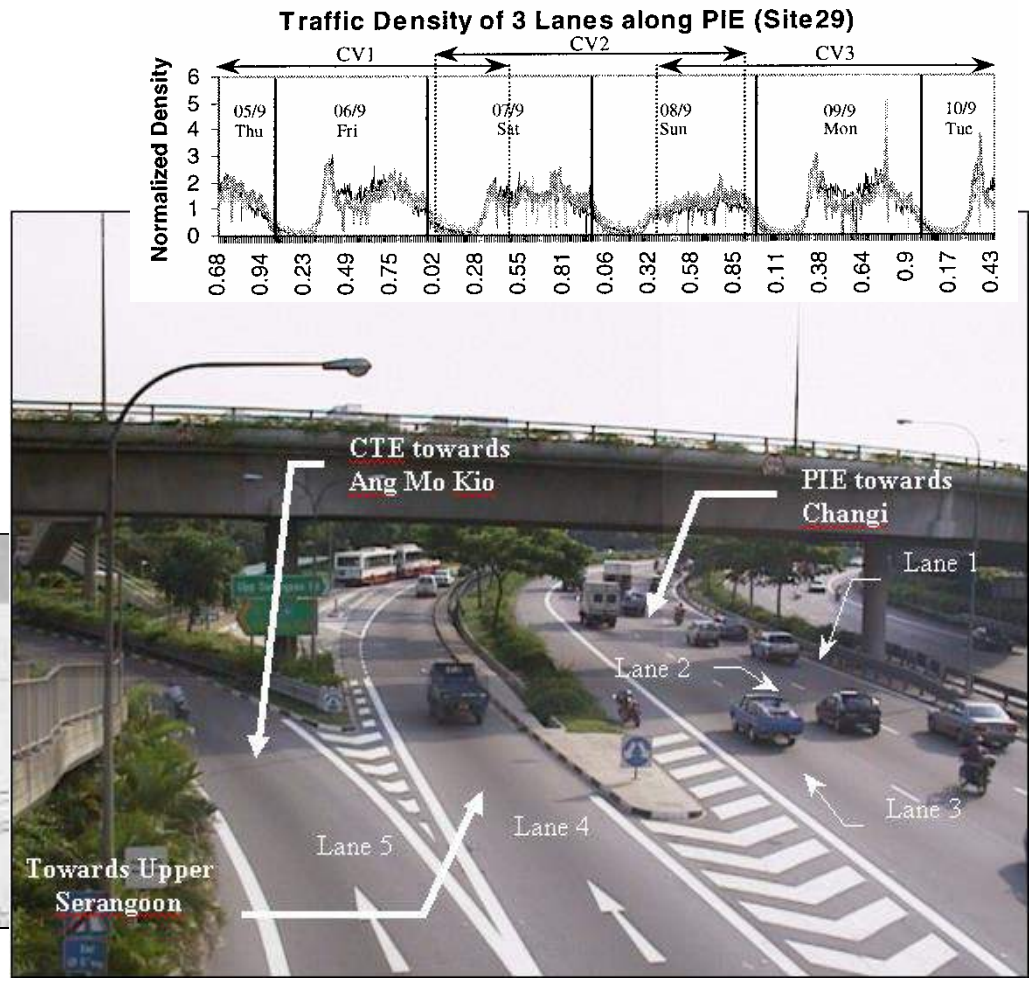


Information Classification: General

Intelligent Traffic Forecasting

- **Traffic Flow Modeling and Prediction**
  - Neural and neuro-fuzzy systems
- **Traffic Estimation**
  - Neural vision





Information Classification: General

Intelligent Vehicle Navigation

Vehicle Navigation and Control

- **Conventional control-based**
- **Computational intelligence-based**
  - **Manually-crafted system**
  - **Adaptive self-organizing system**
    - **Black-box predictive system**
    - **Semantic rule-based system**

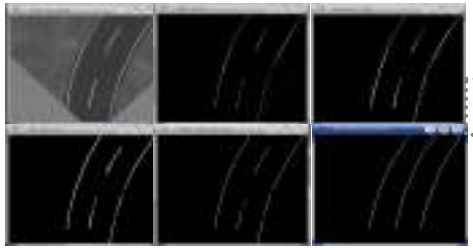
Current ITS technologies: a taxonomy

Chosen methodology: Clear interpretation, human-oriented design

Information Classification: General

Intelligent Car Driving System

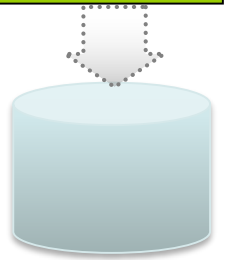
1 Vehicle simulator



Vision system

Proximity sensors

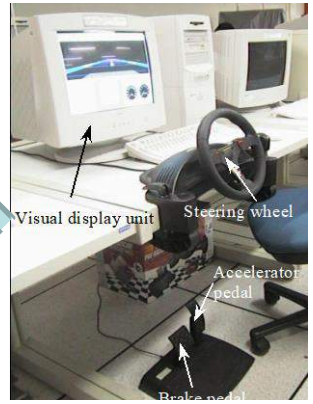
Feature extractor



Feature Database
(e.g., look-ahead distance, curve angle)

2 Feature extraction

Hardware car model



Control consoles

4 Motor system

Cognitive Architecture

An integrated framework comprising brain-inspired neuro-fuzzy rule models of learning, memory and attention

3 Driving agent

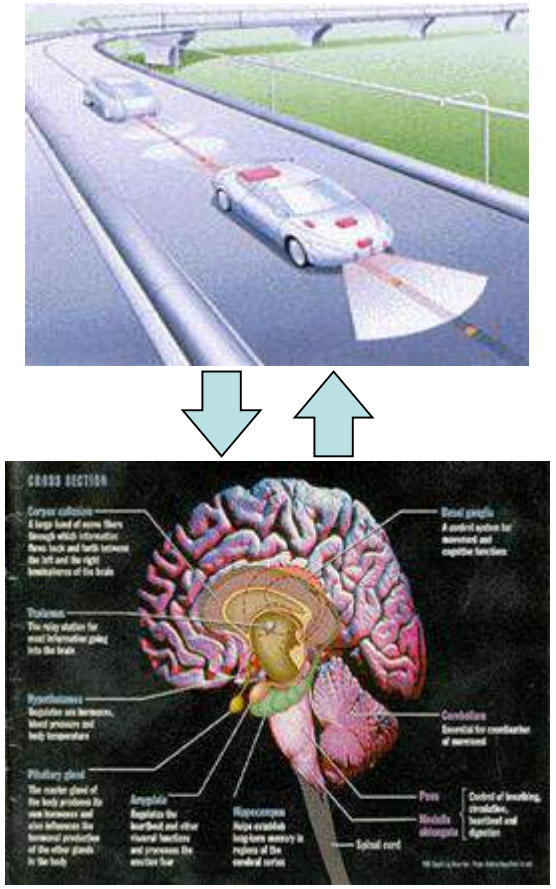
Information Classification: General

Neuro-Cognitive Architectures

- **Convergence of Cognitive Science and Neuroscience**
- **Study of the human mind → new science for AI**
  - Sensing, diagnosis, guidance
  - Semantic learning memory
  - Skill acquisition e.g. driving

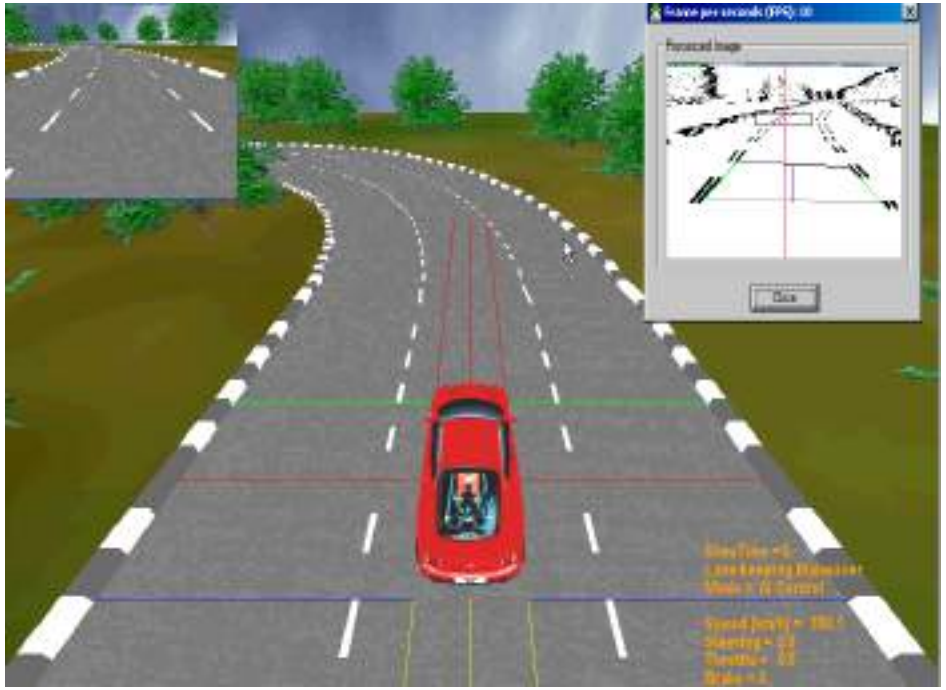
"Example is the way to learn.
Example is the only way to learn."
(A. Einstein)

→ Humanized Intelligent Systems



Information Classification: General

Intelligent Car Driving Manoeuvres



5 Lane-keeping behaviour (lane following)

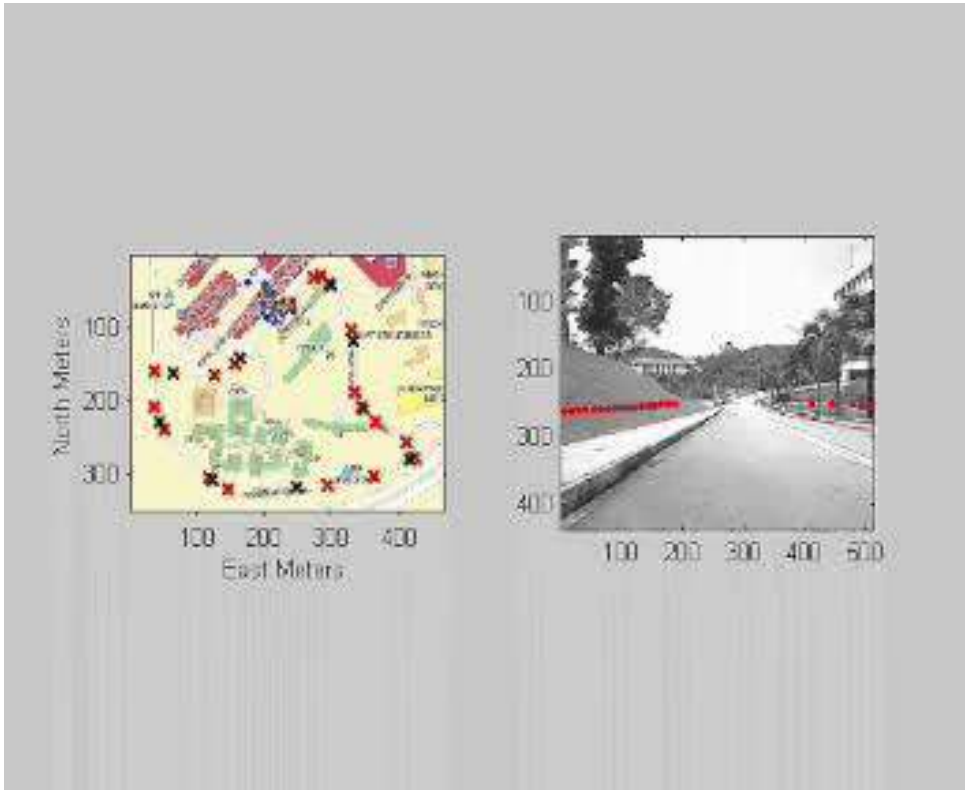
6 Lane-switching behaviour (lane-changing + following)

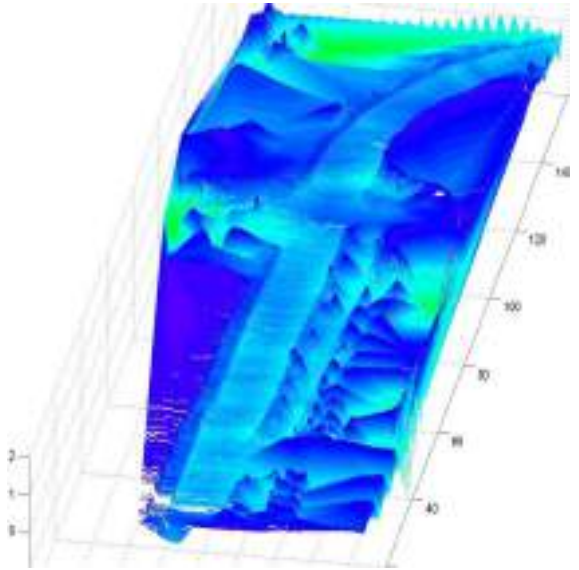
Information Classification: General

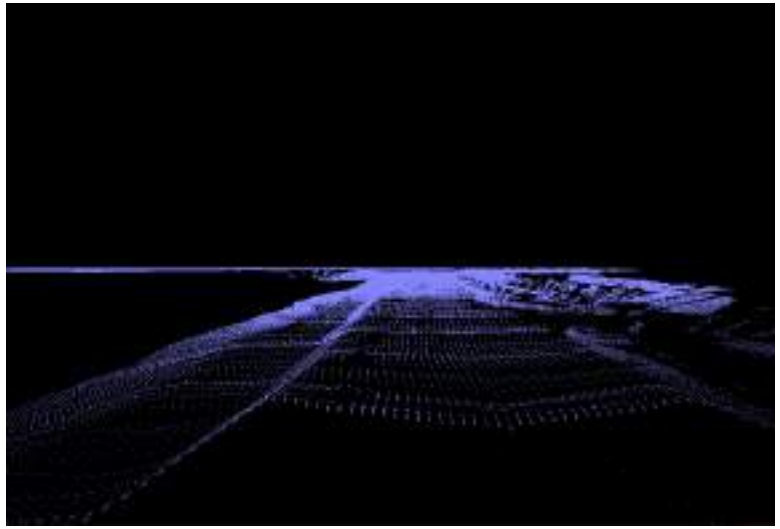
Intelligent Car Driving and Parking

Information Classification: General

Simultaneous Mapping and Localization







Information Classification: General

هيئة الطرق والمواصلات
ROADS & TRANSPORT AUTHORITY

RTA

Capstone Research Project to investigate modes of Personal Transportation

Dr. Michel Pasquier

Dr. Gerassimos Barlas

AUS | American University of Sharjah

Indoor Robot Navigation using Grid-based Maps & Visual Odometry

Omar Sobhy

Gehad Aboarab

Hussain Abbasi

Mohammad Atallah

Outline

Problem Statement

Design Objectives

System Components

Implementa-tion Details

Testing Results

System Limitations

Information Classification: General

Problem Statement

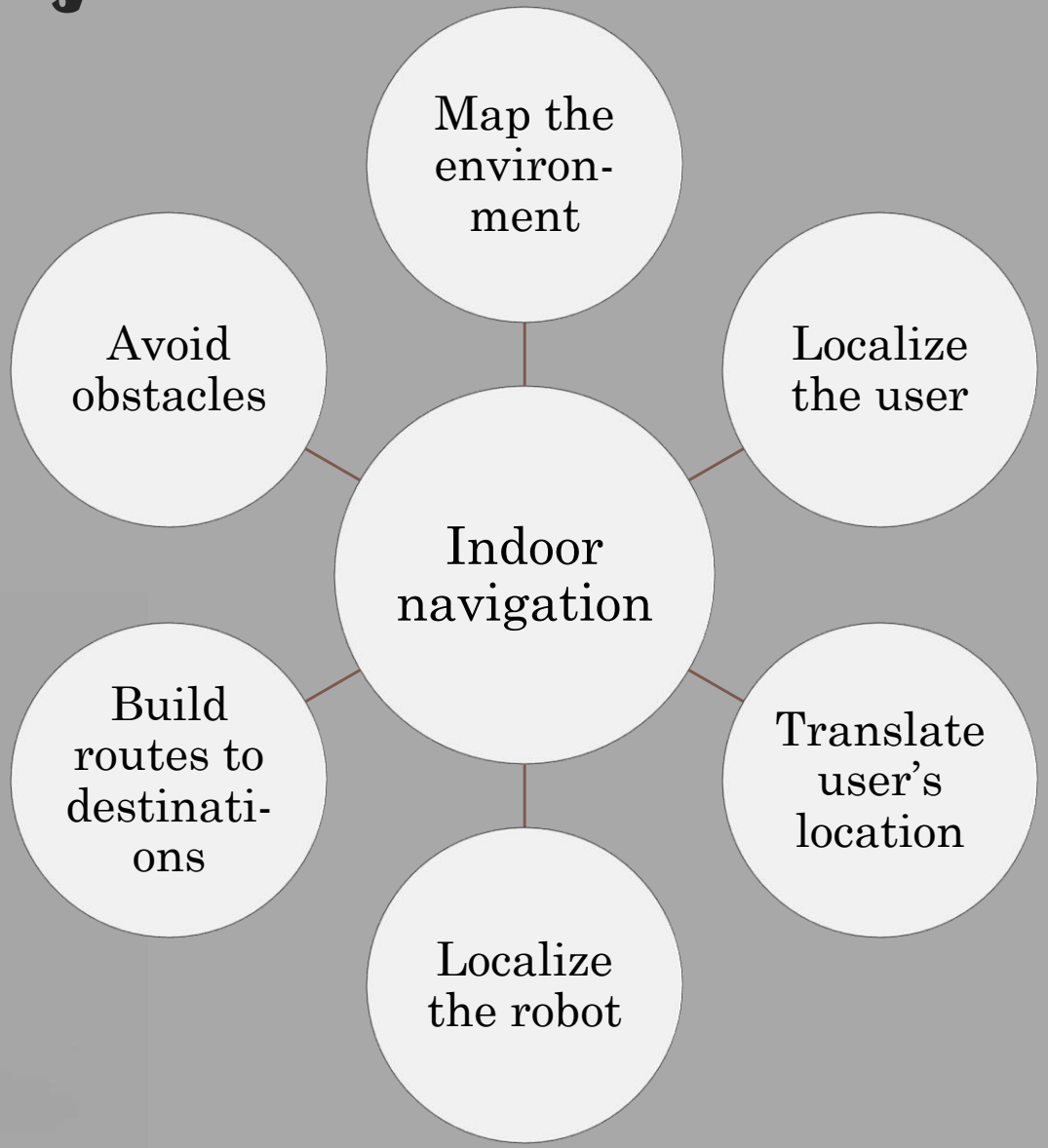
Unfamiliar environment

Lack of indoor transportation

Challenge to learn new maps

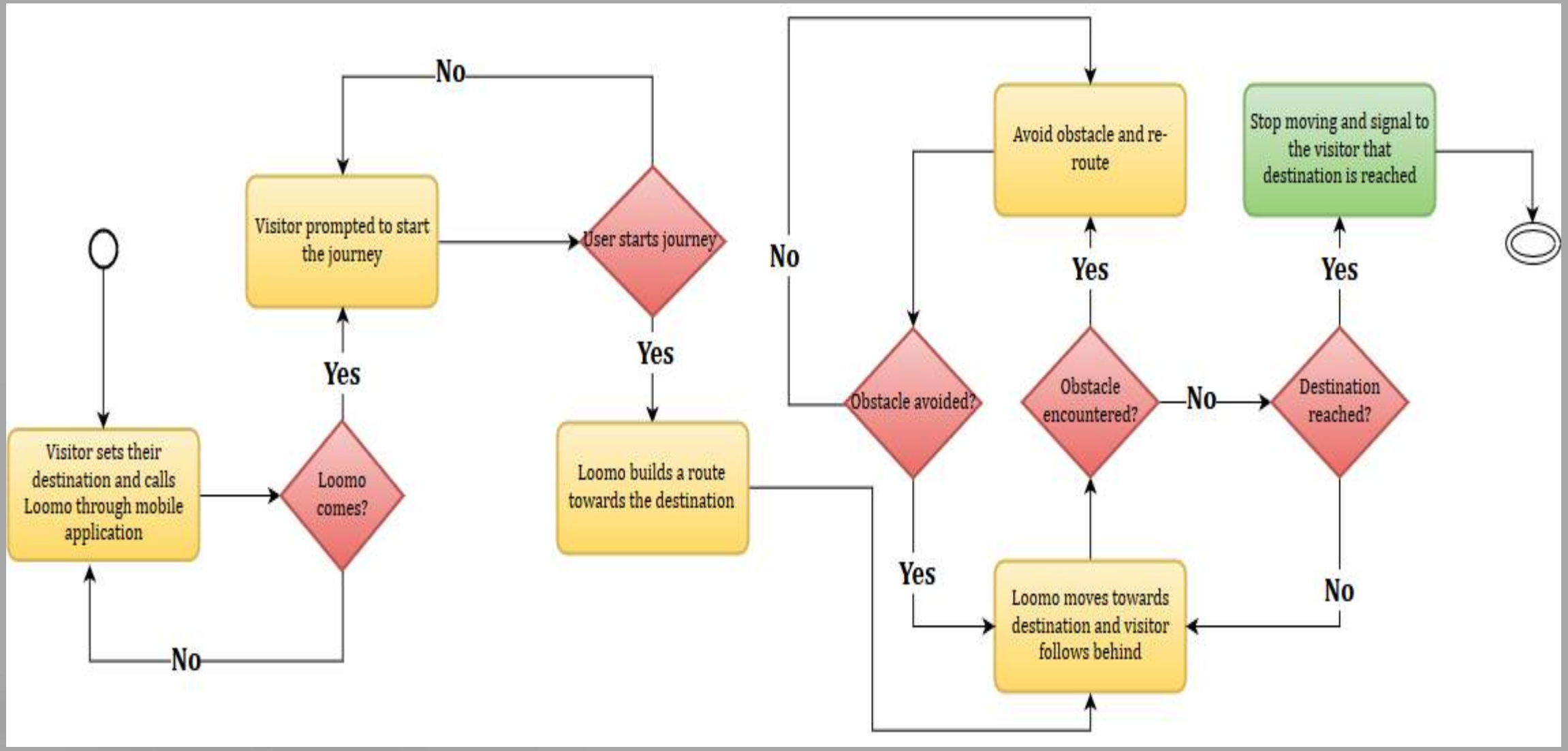
Information Classification: General

Design Objectives



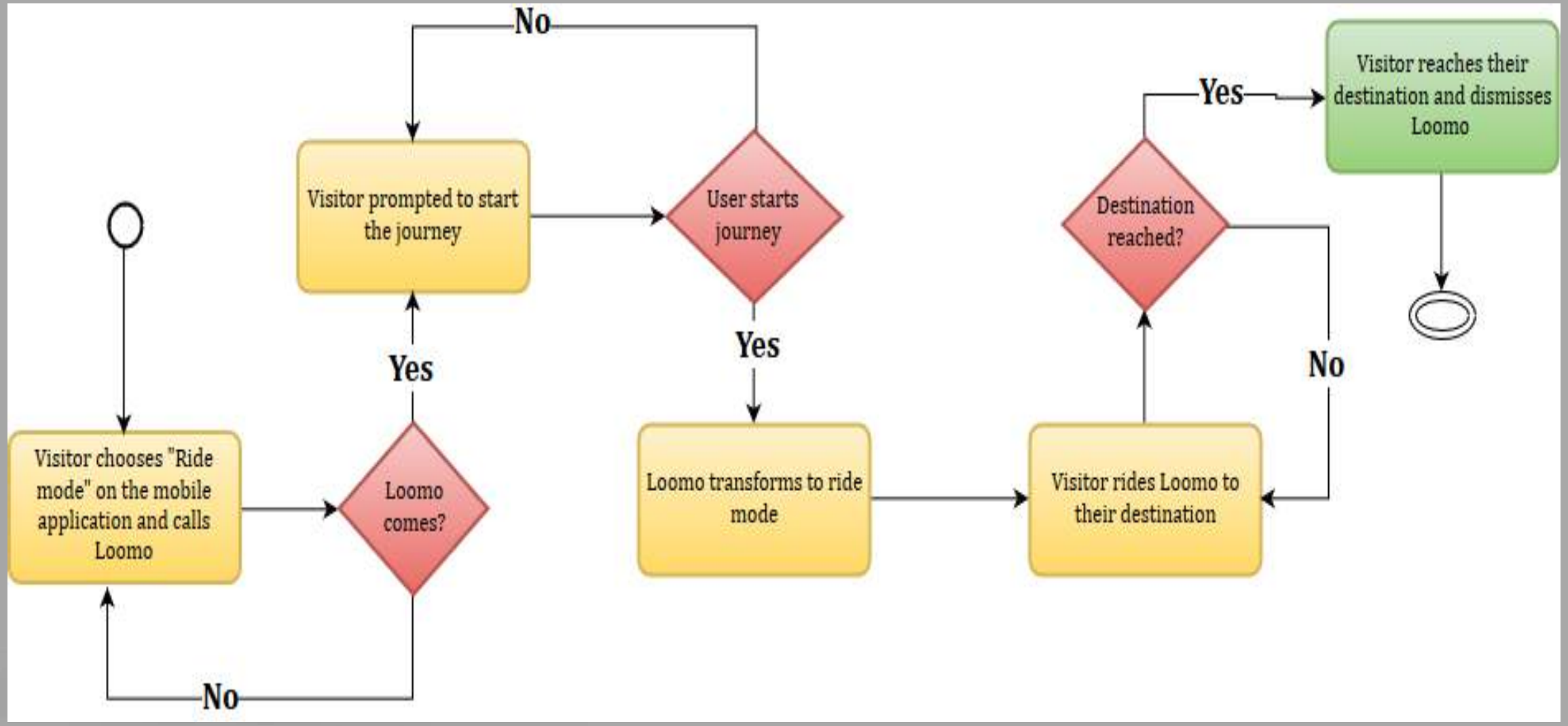
Information Classification: General

Design Objectives
Guide Mode



Information Classification: General

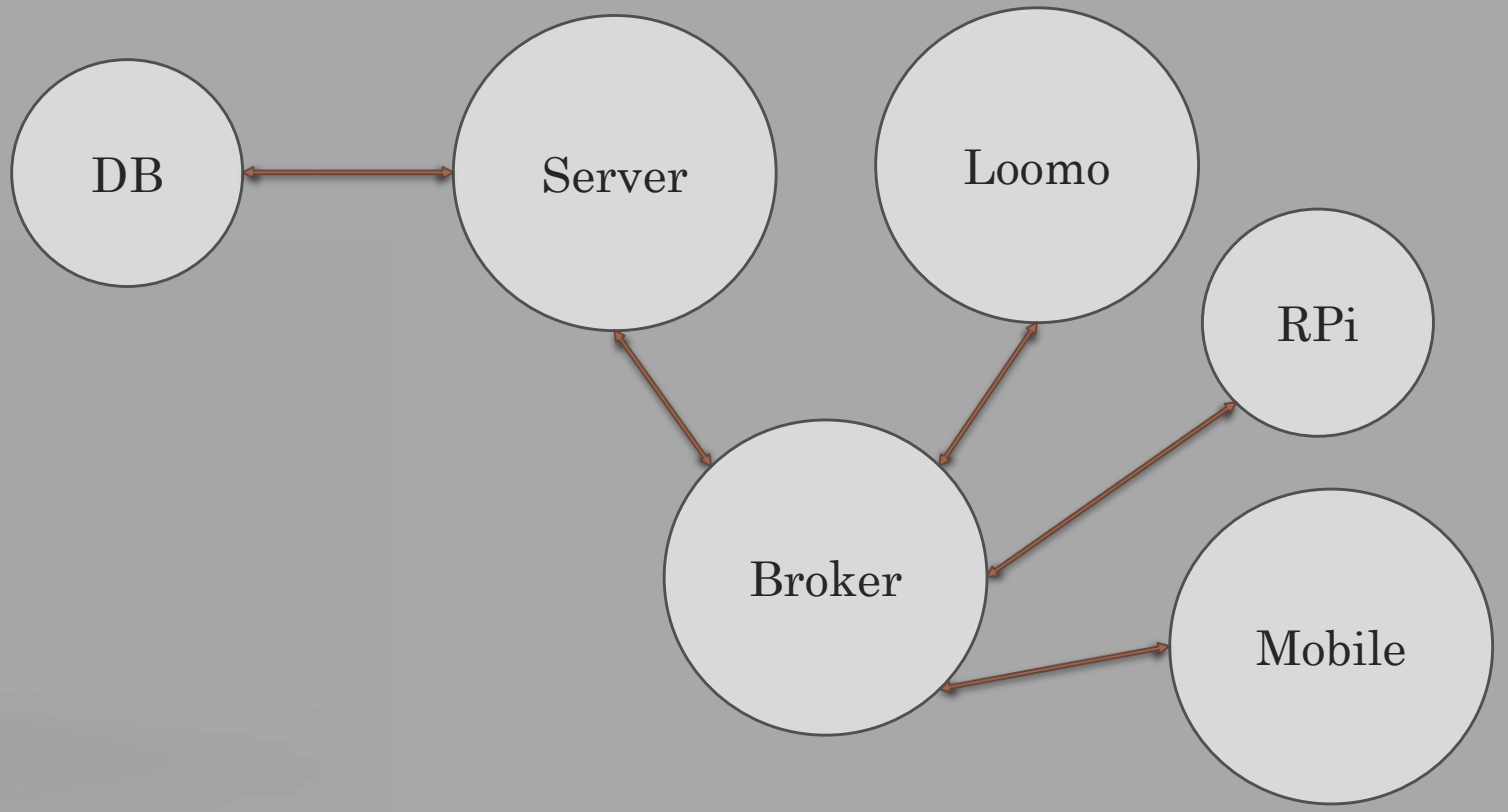
Design Objectives
Ride Mode



Information Classification: General

System Components

- The system is made up of 6 main components
- The components are interdependent on each other

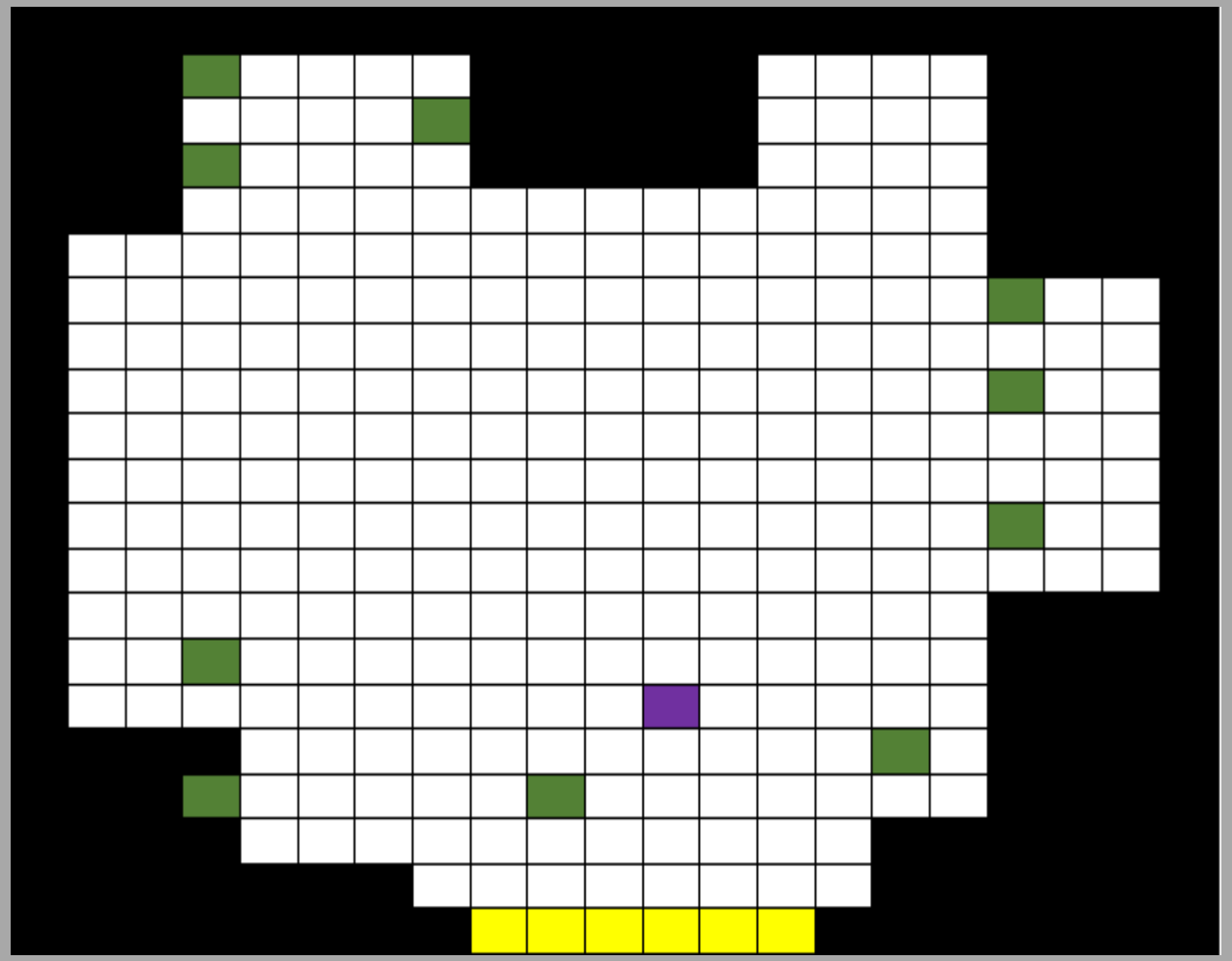


Information Classification: General

Building the Map

- Physical measurements
  - Permanent obstacles
  - Beacon positions
  - Destination coordinates
  - Loomo's home location
- Measurements to coordinates
- Store in database

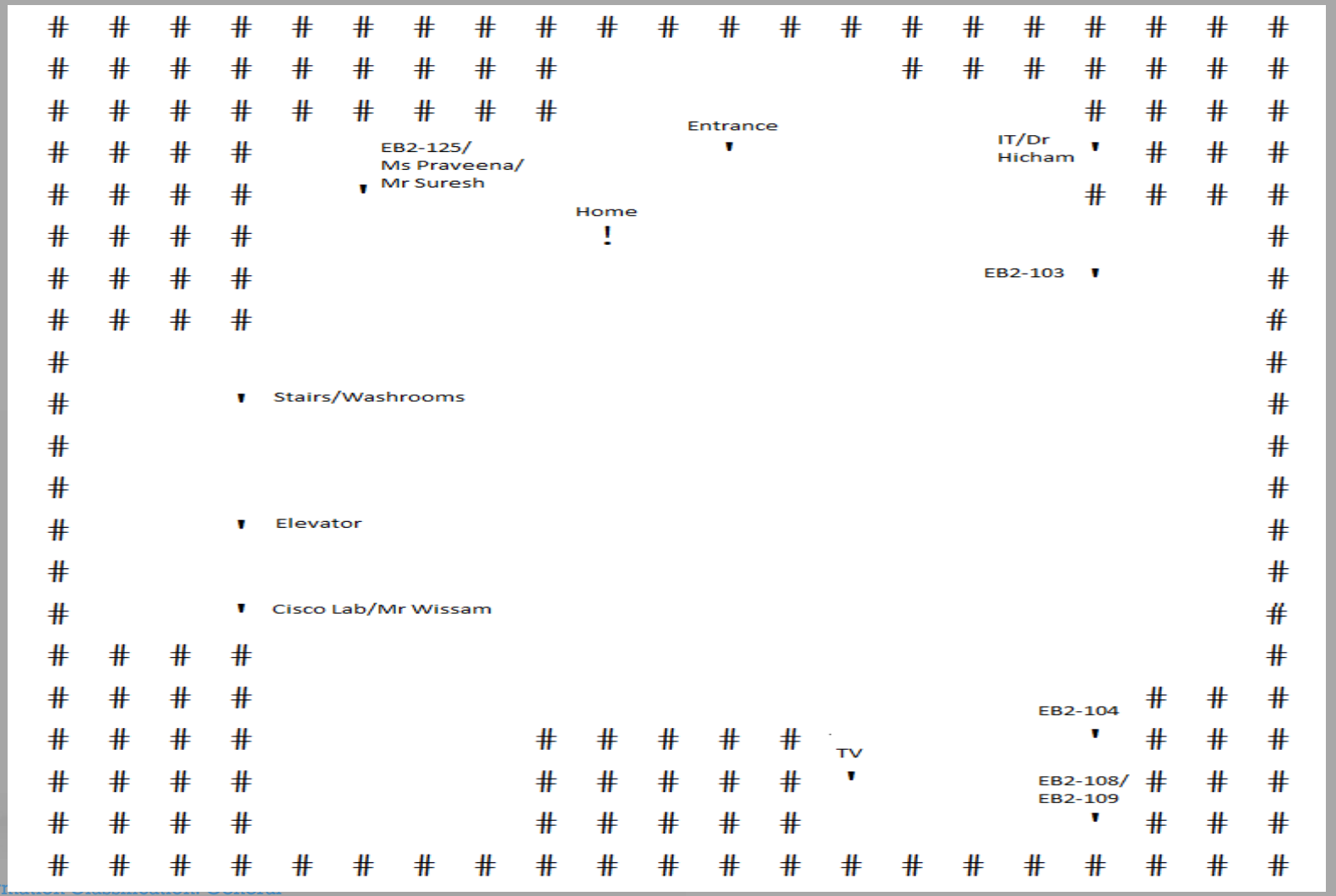
	Loomo Home Station
	Destination
	Obstacle
	Empty
	Entrance



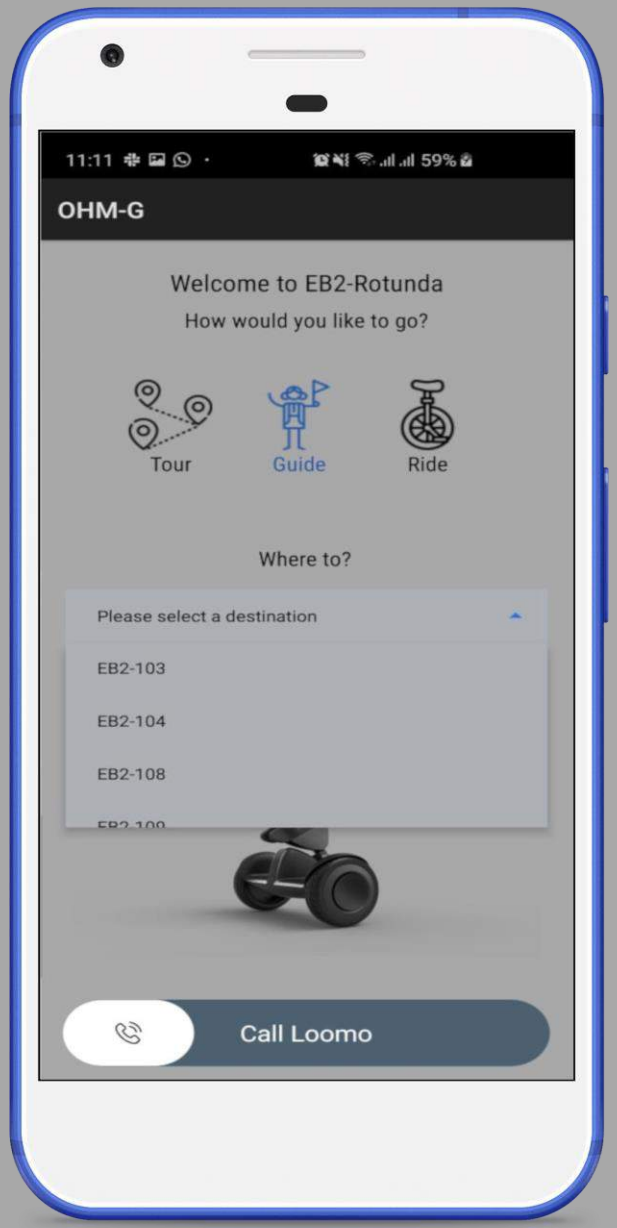
Information Classification: General

Getting the Map

Loomo application map



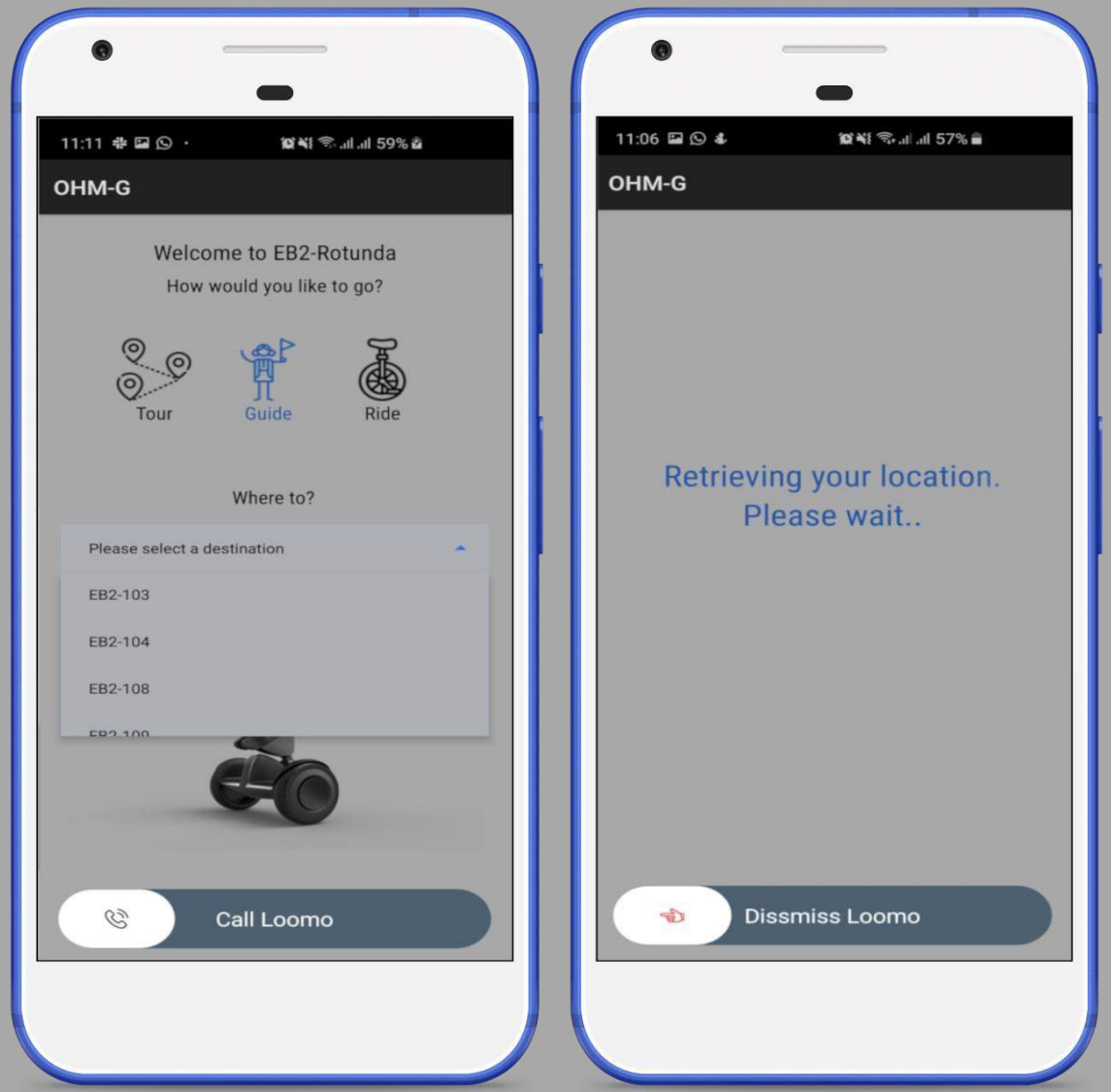
mobile application map



Localizing the User

- Estimote SDK to scan for beacons
- Nearest beacon ID
- Mobile sends beacon ID to server

Retrieving nearest beacon ID on mobile application

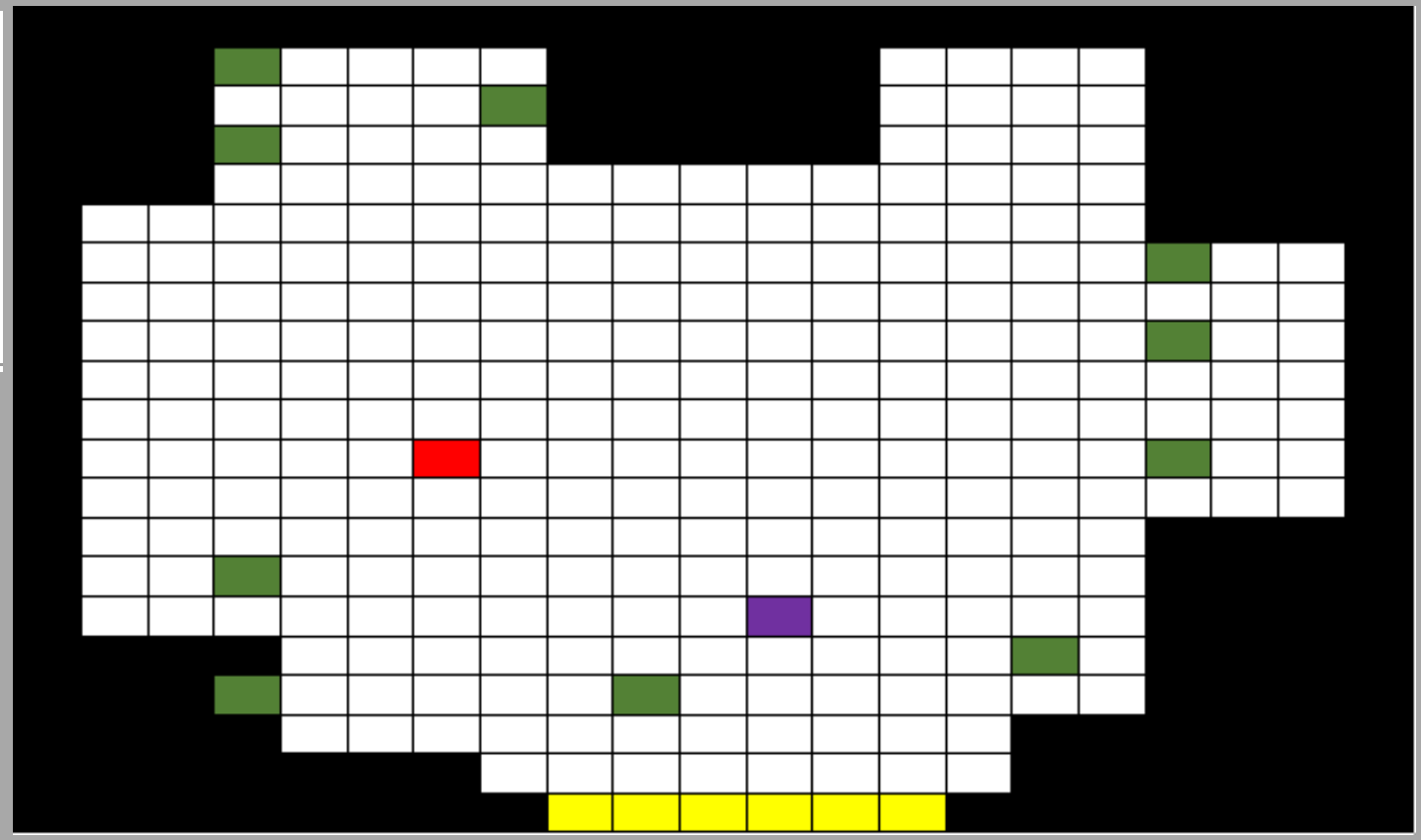


Information Classification: General

Translating User's Location

- Nearest beacon ID → Corresponding beacon coordinate
- Store in the database

	Home Station
	Loomo Location
	Destination
	Obstacle
	Empty
	User Location
X	Route to destination



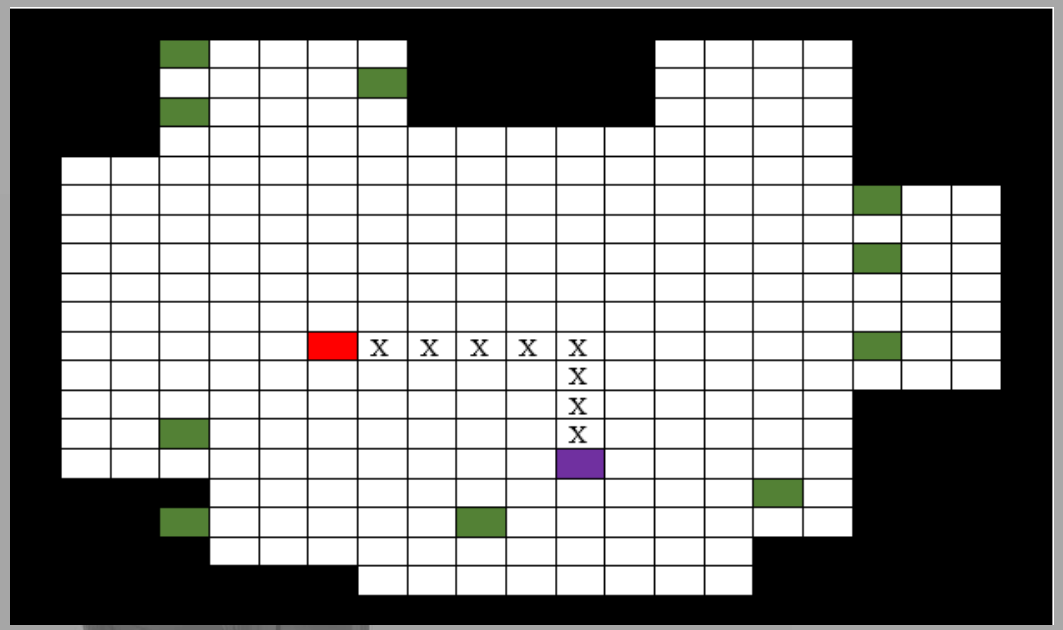
Information Classification: General

Localizing Loomo

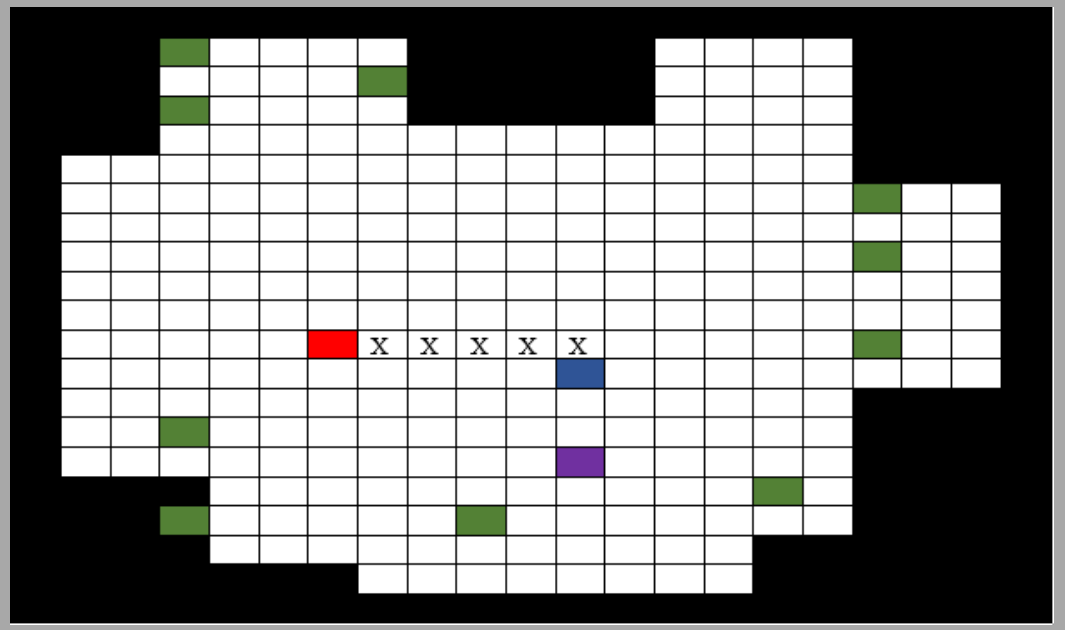
- Upon installation of Loomo application

	Home Station
	Loomo Location
	Destination
	Obstacle
	Empty
	User Location
X	Route to destination

Home: 9,5
LastKnownLocation: 9,5



Home: 9,5
LastKnownLocation: 11,5

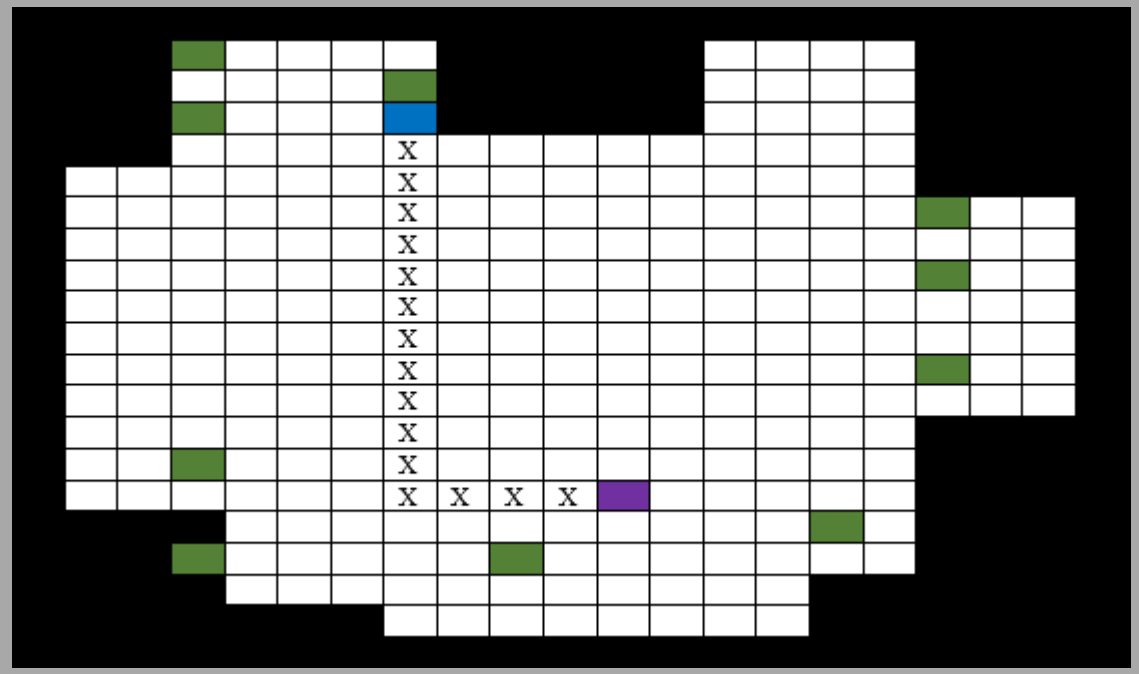


Information Classification: General

Building a Route

- A* algorithm builds route using
  - Map object
  - Current and destination coordinates
  - Permanent obstacles already in place

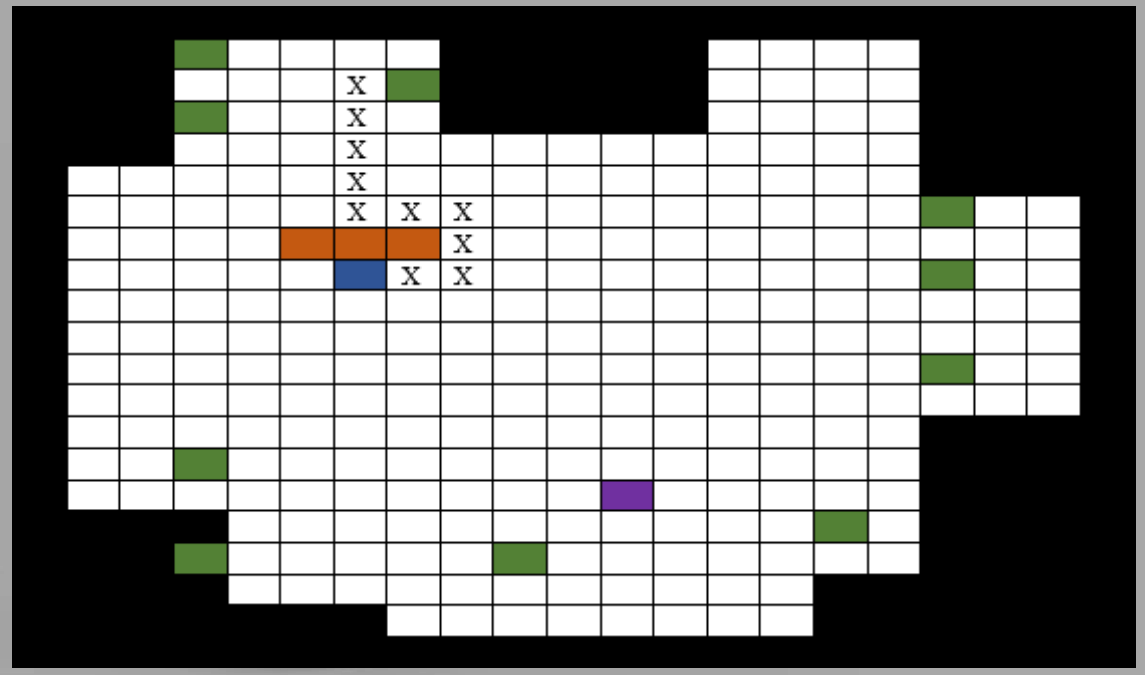
	Home Station
	Loomo Location
	Destination
	Obstacle
	Empty
	User Location
X	Route to destination

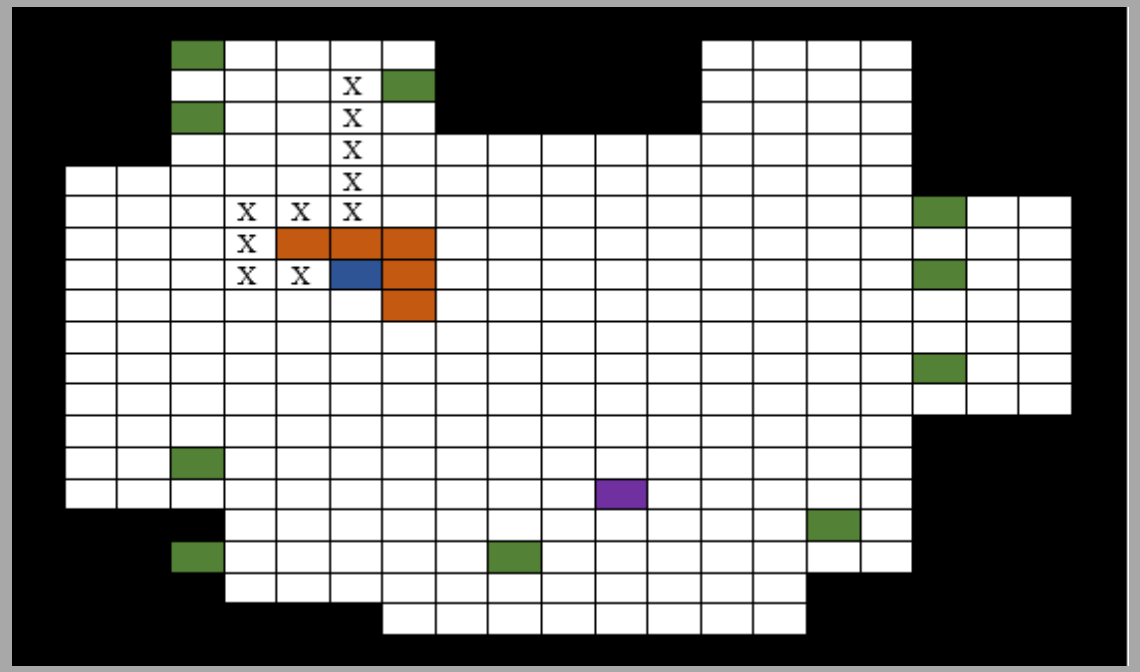


Information Classification: General

Avoiding Obstacles

- D* algorithm places temporary obstacle in map
- Reroutes using:
  - Map object + permanent obstacles already in place
  - Current checkpoint + destination coordinate

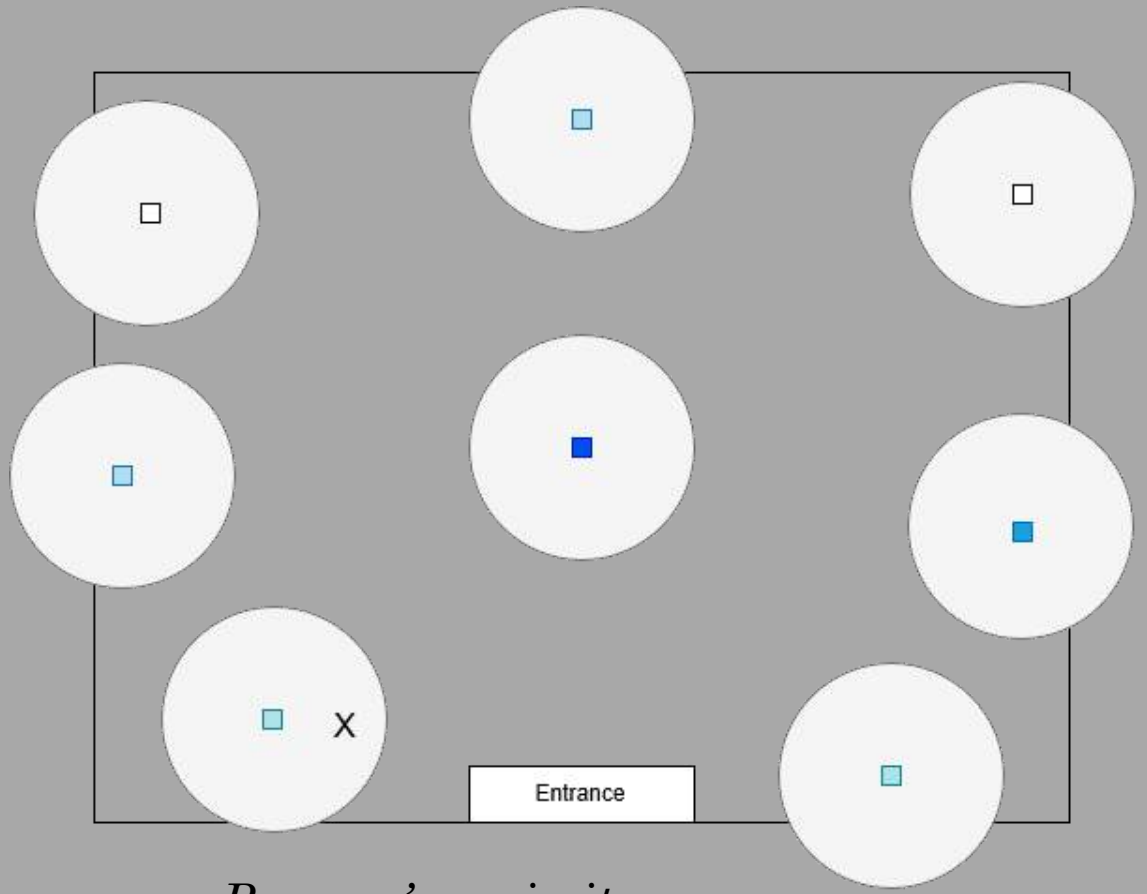




Information Classification: General

Testing Results
Beacons & Mobile Application

- Beacons were placed at different locations in EB2
- The ranges were tested with mobile



Beacons' proximity zones and user location

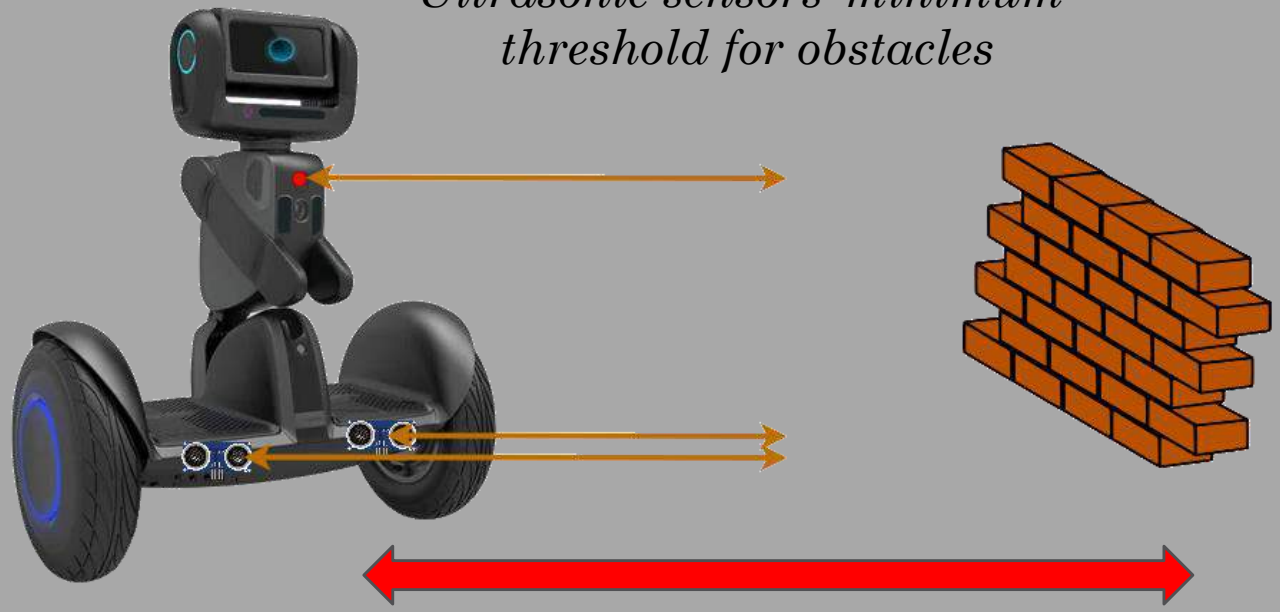
Information Classification: General

Testing Results IV
RPi & Ultrasonic Sensors

- Tested ranges and positioning

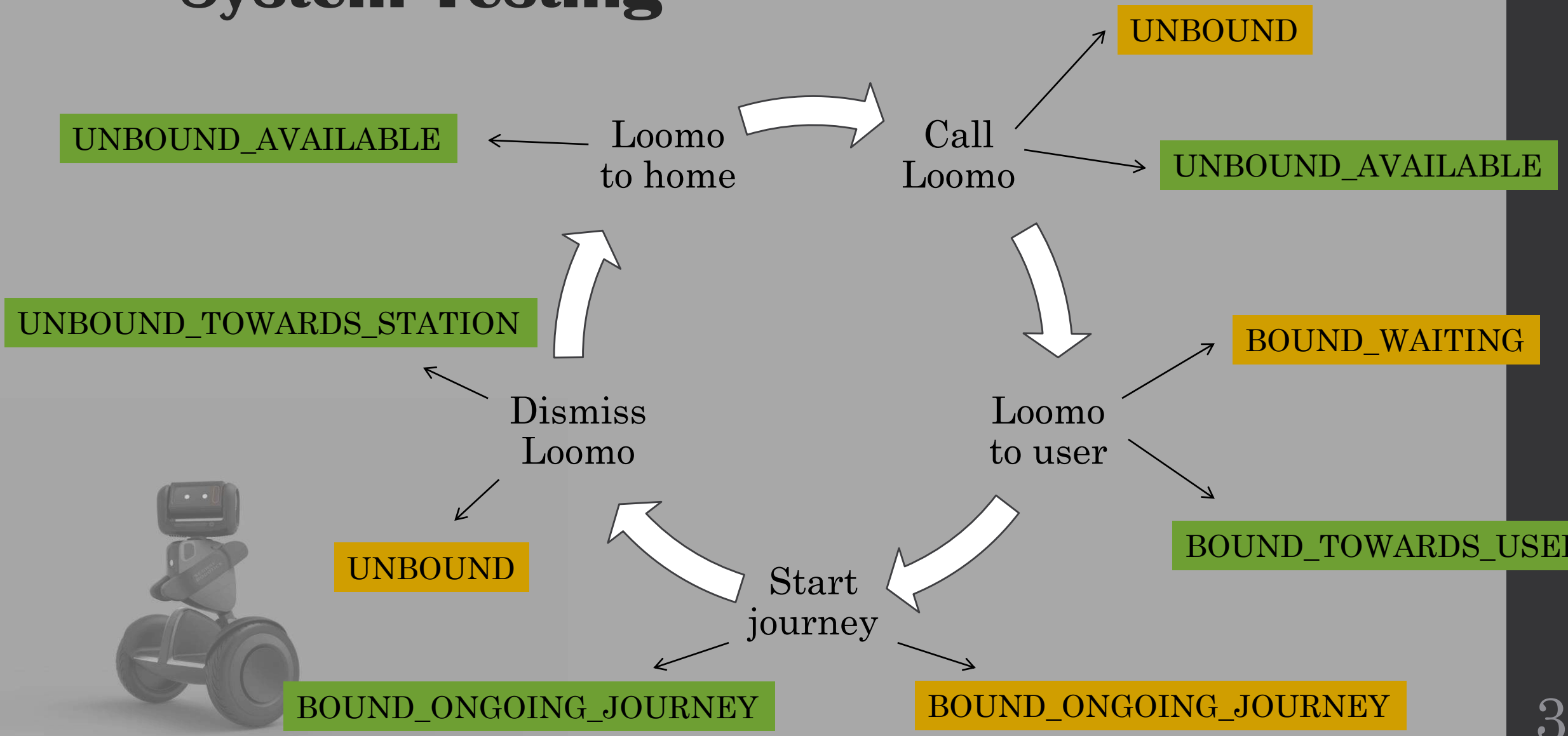
Ultrasonic sensors placement

Ultrasonic sensors' minimum threshold for obstacles



Information Classification: General

System Testing



Information Classification: General

System Limitations

- Loomo SDK
- Manual mapping
- Artificial Landmarks
- Beacon proximity

Information Classification: General

Information Classification: General