Last Mile Intelligent Driving in Urban Mobility

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Why we need it?

What kind of system we proposed?
**Global Megatrends**

**Growing number of population**
- 3.7 billion in 1970
- 7.8 billion in 2020
- 10 billion in 2070

**Increasing of aging population**
Ageing countries
- 1970s-1990s Developed countries of European
- 1990s Japan
- 2020s USA & Russian
- 2030s China
- 2045 Global

**Continued urbanization & Growing number of megacities**
Urban population proportion
- 24.4% in 1950
- 57.5% in 2020
- 67.8% in 2050

**Energy saving & Environment protection**

<table>
<thead>
<tr>
<th>Life Style in Future → Needs in Urban Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A shortage of city parking space</strong></td>
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<tr>
<td><strong>Increasing of aging population</strong></td>
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<tr>
<td><strong>Increasing of satellite city</strong></td>
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<td><strong>New energy car sharing</strong></td>
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</table>
Proposed Last Mile Intelligent Driving - Functions

**Monitoring**
- Search parking lot or charging spot.
- Start last mile or auto parking function.
- Display travelling track, around view and vehicle status.

**Auto Driving**
- Autonomously driving to the parking lot or wireless charging spot.

**Auto Parking**
- Parking lot detection and automatic parallel parking or vertical parking.

**Auto Retrieving**
- Autonomously getting out of parking lot and driving back to the position of driver.
**Proposed Last Mile Intelligent Driving - Specifications**

### Auto Driving
- Functions: Lane Keeping Control, Adaptive Cruise Control
- Speed ≤ 10km/h

### Auto Parking
- Functions: Parking Lot Detection, Parallel & Vertical Parking, 360° Bird’s Eye View Monitoring

<table>
<thead>
<tr>
<th>Type</th>
<th>Parallel Parking</th>
<th>Vertical Parking</th>
</tr>
</thead>
</table>
| **Constrains (m)**    | Heading angle |θ| ≤ 30°
Distance to parking lot edge 0.3 ≤ D ≤ 1.8                                      | Heading angle |θ| ≤ 30°
Distance to parking lot edge D ≥ 2.5m                                             |
| **Front & Back Safety Distance (m)** | 0.30                                                           | N/A                                                                            |
| **Min. Length L_{min} (m)** | Length of Vehicle + 0.7                                   | N/A                                                                            |
| **Effect of Parking**  | Heading angle |α| ≤ 5°
Distance to parking lot edge or obstacle 0.2m < W < 0.4m                        | Heading angle |β| ≤ 2° |

![Diagram](image)

*Note: Diagrams show the orientation and constraints for parallel and vertical parking.*
Proposed Last Mile Intelligent Driving - Specifications

Auto Retrieving
- Functions: Getting out of parking lot, Auto Driving

Monitoring
- Onboard Monitoring (iPad)
  - Output of Vehicle Traveling Track & 360° Bird’s Eye View
  - Input of Operation Command
- Remote Monitoring (iPhone)
  - Output of Vehicle Traveling Track & Vehicle Status
  - Input of Operation Command (Remote Control & Searching Parking Lot, etc.)

Advantage
- Autonomous driving in urban traffic
- Fully automatic parking
Proposed Last Mile Intelligent Driving - Configuration

Roewe E50 Intelligent Driving System

- **GPS**: Accurate positioning, and realizing autonomous navigation
- **Mono Camera**: Lane detection and realizing lane keeping
- **IPad**: Display moving trajectory and around view of car
- **MMW Radar**: Detecting forward obstacle for ACC
- **LIDAR**: 4 LIDARs at each corner for parking lot accurate detection
- **Around View Camera**: 4 cameras around the body constructing the bird’s eye view, used for detection of parking lot line and monitoring
- **Ultrasonic Radar**: -Front & back each 3 for detecting near obstacle -Left & right each 1 for detecting parking lot
- **Controller**: Perception, behavior decision & planning, chassis control for intelligent driving

Last Mile Intelligent Driving in Urban Mobility
Proposed Last Mile Intelligent Driving - Demo

**Place**  
Jiading Campus, Tongji University

**Date**  
October, 2014

**Event**  
The 16th China International Industry Fair (Shanghai, November 4-8, 2014)

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**Last Mile Intelligent Driving Functions**

- Auto Driving
- Auto Parking
- Auto Retrieving
- Monitoring

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Thanks for your attention!

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陈慧
同济大学 汽车学院/新能源汽车工程中心
Future Work

● “最后一公里”结合新能源汽车的分时租赁，实现顾客一键取车、还车、电动车自动充电。

● 在将“最后一公里”智能驾驶功能实现产品化还需完善的工作：
  a) 提高系统可靠性：通过多传感器信息融合使环境感知更加精准可靠，提高泊车精度及无人驾驶安全可靠性；
  b) 提高智能驾驶性能：GPS结合传感器估计的定位导航，实现各种环境的无人驾驶及泊车。
  c) 增强用户体验：结合车联网技术实现实时互联驾驶体验
  d) 提高系统集成度，降低成本
智能驾驶系统构成

- 传感器主要参数

<table>
<thead>
<tr>
<th>设备名称</th>
<th>型号</th>
<th>主要参数</th>
<th>供应商</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS全球定位系统</td>
<td>RT3002</td>
<td>刷新频率100Hz；定位精度1.5m（无基站）/0.02m（有基站）；航向角0.1°；速度精度0.05km/h；</td>
<td>北京诺耕</td>
</tr>
<tr>
<td>单目摄像头</td>
<td>VisLab Embedded Lane Detector</td>
<td>IEEE-1394数字摄像头；Micron MT9V022 1/3”CMOS图像传感器；像素752×480；</td>
<td>VisLab</td>
</tr>
<tr>
<td>毫米波雷达</td>
<td>Delphi ESR</td>
<td>频率76GHz，刷新频率20Hz，检测距离1<del>175m（长距离）/0.5</del>60m（中距离）；</td>
<td>Delphi</td>
</tr>
<tr>
<td>激光雷达</td>
<td>Hokuyo UTM-30LX</td>
<td>检测距离30m，角分辨率0.25°；</td>
<td>Hokuyo</td>
</tr>
<tr>
<td>超声波雷达</td>
<td>希牧30066006</td>
<td>测量有效范围：23cm-150cm；精度1cm；数据更新周期：30ms；</td>
<td>海康</td>
</tr>
<tr>
<td>环视摄像头</td>
<td>CAM-V02</td>
<td>视野范围：185.0度（水平），142.4度（垂直）；分辨率：648 x 488pixle</td>
<td>无锡维森</td>
</tr>
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