Summary of SIP-adus Project (FY2016)

Name of the project	Studies of sensing technologies relating to an precision docking control in a next-generation urban transportation system
Responsible Organization	Advanced Smart Mobility Co.,Ltd.
Name	Keiji Aoki

Object of the Project

The accuracy precision docking system is required in the Advanced Rapid System(ART). A method based on route guidance has been considered. However, there are many disrupting factors where white line is covered by obstacles and white line is missing due to deterioration.

Accordingly, investigations and studies are made with respect to flexible route guidance technology for an precision docking control which does not rely on white lines, displays and the like fixed on a road surface and exhibits further high robustness including countermeasures against obstacles on a road and missing of the white lines.

Project Summary

1. Studies of sensing technologies

Regarding the sensing technology related to the precision docking control of the ART bus, we searched the following five methods and compare each result.

1) High-solar reflective coating material
2) Vehicle-mounted LiDAR
3) Magnetic marker and vehicle-mounted sensor
4) Image recognition
5) Road surface reflection of laser beam

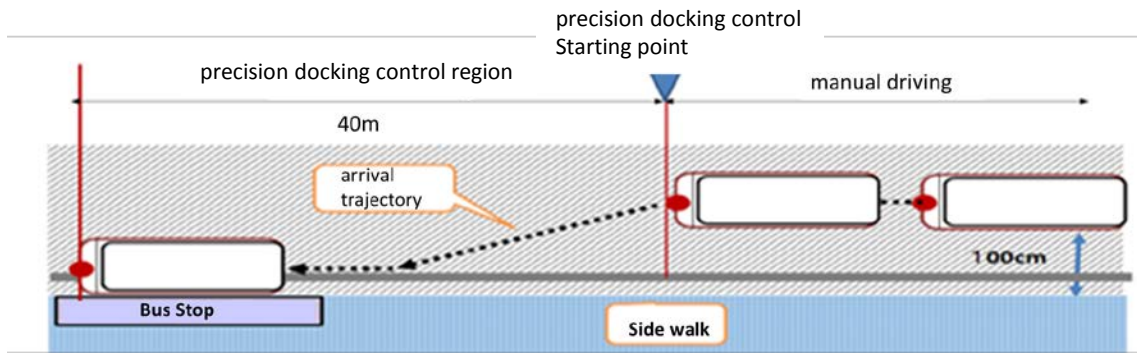
Position Detection Method	Sensing (Precision Docking)	Sensing (Approach)	Workability	Robustness (Environment)	Cost (Road,Vehicle)	Evaluation
1) High-solar reflective coating material	△	○	△	X (Rain)	△ (Camera)	△
2) Vehicle-mounted LiDAR	○ (line stone)	X (Not line stone)	○	△ (Hard Rain,Snow)	○ (used in common)	◎
3) Magnetic marker and vehicle-mounted sensor	△	○	△	○	△	○
4) Image recognition	X	△	△	△ (Night,Rain)	○	△
5) Road surface reflection of laser beam	X	X	△	X (Rain)	○ (used in common)	X

2. Actual vehicle evaluation

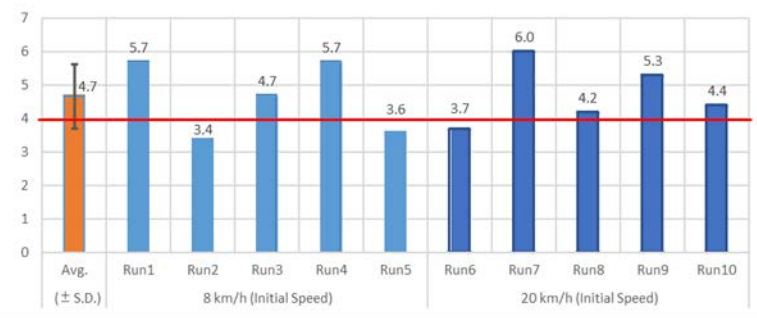
By comparing and considering the above-mentioned five kinds of sensing technologies, it is found that feasibility of the technology 2) and feasibility of the technology 3) are high. Among both the technology 2) and the technology 3), accuracy of the precision docking using the technology 2) is relatively higher and hence, an actual vehicle evaluation is performed using the technology 2).

In the actual vehicle evaluation, at the time of performing an precision docking at a bus stop at a position 40 m ahead, an error from the bus stop with respect to a target distance (4.0±2.0cm) is measured.

As a result, an average precision docking value is 4.7 cm and a maximum error is +2.0 cm so that it is achieved that a target error range of ±2.0cm.



Result : Achieved precision docking with an accuracy of ±2 cm using technology 2)
Issue : In the approach to the bus stop such as within the intersection it is necessary to combine different methods.



Final gap (Door and Line stone) [cm]

Future plan

1. Major issues of the precision docking using LiDAR
   - Technology : Including the approach part to the bus stop (intersection part and part without curb), it is difficult to the precision docking using LiDAR alone.
   - Robustness : Insufficient robustness against weather condition(Especially heavy rain, snow, fog, etc.).
   - Cost : Even in combination with other technologies, the cost is still high.

2. Content to be addressed
   - it is necessary to combine with sensing technology that can be used in approach part to the bus stop such as GPS.
   - Consider feasibility of bus stop structure corresponding to final precision docking technology (line stone, landmark object, etc.).