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Article

Safety Lighting Sensor Robots Communicate in the Middle of the Highway/Roads

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Abstract: The object of this research is designing of new robot-to-robot communication system working in the middle of highway/roads to support mobile safety for approaching vehicles. The result of research project directs to a group of safety robot devices which induce a vehicle on a bypass route, as a vehicle guidance method using the same, and a vehicle safety guidance system. According to an embodiment of the present invention, a safety device includes a detector configured to detect a vehicle approaching the safety device, and an image projector configured to project an image onto a road surface approaching the vehicle when the detector recognizes an approach of the vehicle. It can include. According to the present invention, when it is necessary to guide the vehicle to the bypass route, the driver of the vehicle can grasp the detour route in time and move the vehicle to the next lane.

Keywords: sensor robot; causal inference; robot communication; safety lighting; mobile application; ad-hoc network

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1. Introduction

Car accidents in recent years, have their own logs based on data including situation information. There has been increasing interest in predicting/preventing the car accident in the middle of the highway/roads. A lot of traffic research projects have been focused not on users(drivers), but on vehicles. On the other perspective, commuters in metropolitan/urban areas tend to keep safety in their journey out of car accidents of others.

The research on smart highway was triggered by Korean government which supports a convenient and intelligent driver context to decrease accidents by facilitating vehicle, environmental, road

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information.[1] Hong et al.[2] also suggested safety light module also working as localized sensor unit of intelligent transportation systems[3] in the middle of the highway.

Software as well as device has widely developed for road safety over a variety of countries. Most recently, advanced model for real-time vehicle traffic applications[4] were proposed in the sensor network. For former examples, roadside warning[5] sensor had developed in its application and emerging technology enables vehicle control in more automated[6] way even in emergent contexts.

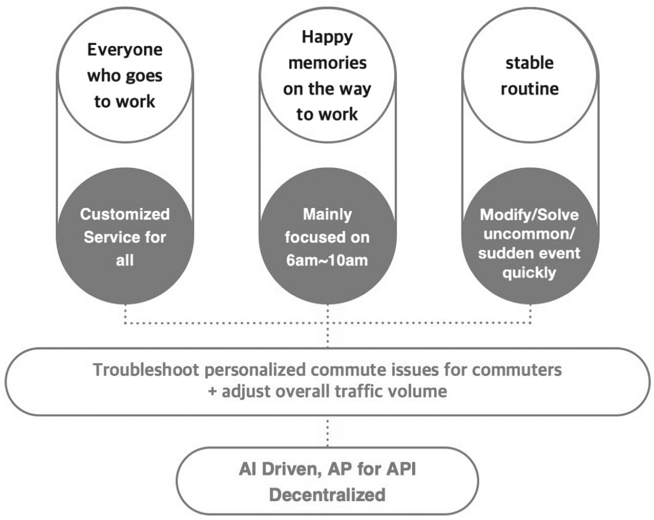

Figure 1. Target: user experience concepts and principles.

The aims of the research is proposing multiple access point robots in the highway/roads, to provide useful information simultaneously with safety and convenience for users. Real-time communicative sensor robot system request users, firstly to detour busy road to prevent secondary vehicle accident, or secondly to select alternatives among other transportation matters in their enhanced experiences. For these purposes, mobile application simultaneously connecting with open APIs become useful for providing information.

2. Research Background and Understanding Context

As an example of a road that requires a detour of a vehicle, there can be a damaged section[7] in which a road used by the vehicle is temporarily unavailable. In this case, the driver of the vehicle must know the route to be detoured and detour the vehicle to the route. For another instance, when a road is under construction or there is a traffic accident, the driver of a vehicle approaching the section needs to identify a route that can be bypassed. In this case, it is usually all that the safety personnel or safety mannequins are arranged. This is a problem that increases the time-consuming risk of accident because the driver of the vehicle can't grasp the bypass route in time.

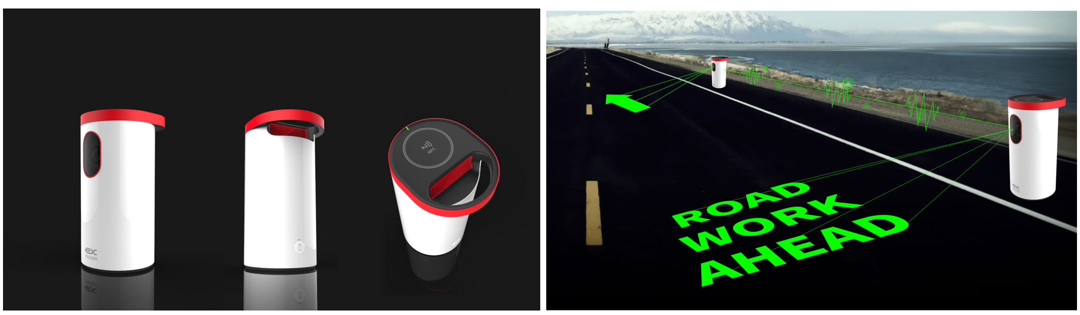

Figure 2. First draft version of safety lighting device as a function module of robot communication.[2]

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We previously designed a draft version of safety lighting device for generating a relative narrow, intense light beam to prevent car accidents while driving at night.[2] One more research has an object to enable the driver of the vehicle to timely determine the bypass path to move the vehicle to the bypass path when it is necessary to guide the vehicle to the bypass path. In addition, the research has a goal to efficiently recognize the driver of the vehicle that the road is in an unusable state.

2.1. Data Science in the Road

2.1.1. Causal inference

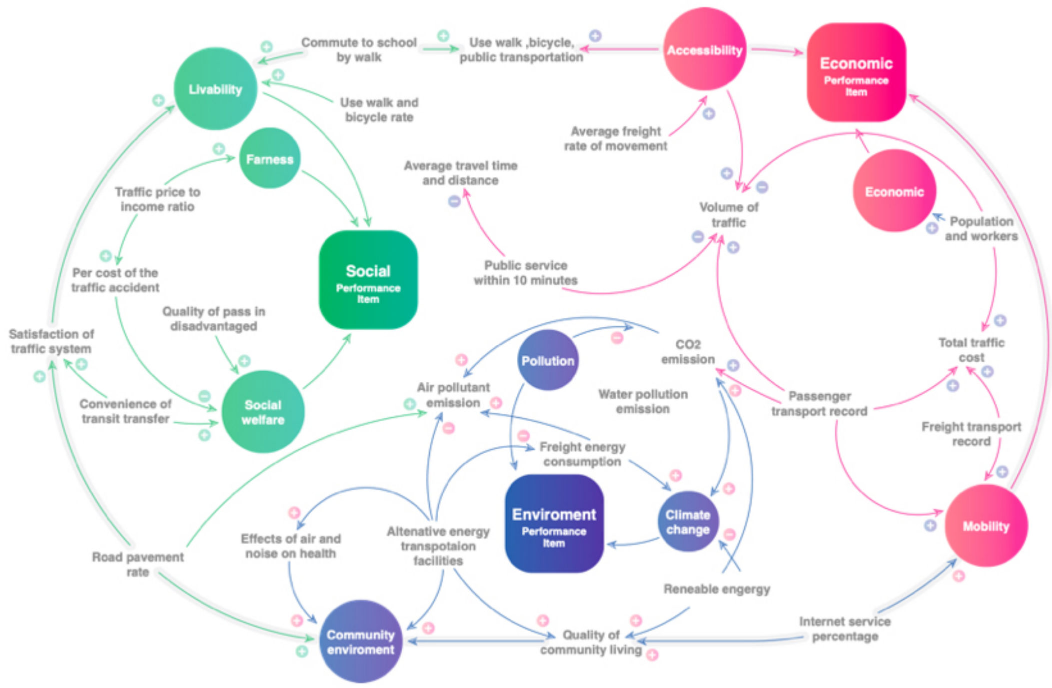

Figure 3. System Dynamics Diagram: Social, economic, environment around mobility industry.[10]

A considerable amount of research has been carried out regarding the road safety with causality. To answer the question if some factors has any effect in reducing the number of road traffic crashes, most of the published paper used regression models with observational data. The low pavement marking visibility can cause for rate of accidents at night than during the day, comparing of two popular methods:

- Potential Outcomes Framework
- Causal Diagrams framework

In the field of road safety, data are restricted to drivers and vehicles involved in road accidents only. To solve selection bias problem, responsibility analyses to evaluate the effect of a given factor on the risk of accident. [18]

2.1.2. Sensor communication system for user in the road

For the purpose of interacting between sign systems and driver having contextual knowledge, there is a need for a technique for solving the above problems. Previously from the construction place, automated behavior system discloses a traffic guide mannequin robot device. However, it still does not solve the dangerous spot identifying problem above. According to the additional research, in order to identify the safe section, and in order to manage the place risk of high accident rate, worker/driver safety problems are existing in the highway road work ahead.

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Against problems, present research results have object to, according to any one of the problem solving methods of the present invention results, which are possible to:

- Improve the visibility of recognizing the information that the driver of the vehicle to move to the bypass path when it is necessary to guide the vehicle to the bypass path at night.
- Increase the level of safety and accident prevention when road management.
- Inform the driver of the detour route efficiently to bypass the unusable road so that the safe driving, and enable the driver to try to avoid the unavailable road to effectively inform the detour route to drive safely.

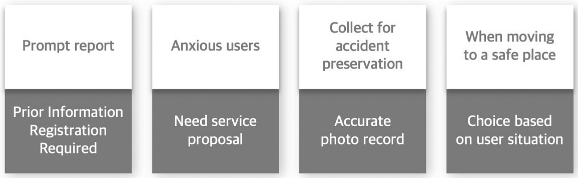

Figure 4. Insights from voice-of-customer besides car accidental area.

2.1.3. Technical answers to the situational problems

As a technical answers for achieving the above contextual problems, according to a first aspect of the research, as a robot device, a recognizing unit for detecting a vehicle approaching the robot device and the vehicle when the recognizing unit detects the approach of the vehicle It can include an image projection unit for projecting an image on the approaching road surface.

Second, there is provided a vehicle guidance method performed by a robot device, the method comprising: detecting a vehicle approaching the robot device, and detecting the approach of the vehicle to display an image on a road surface approaching the vehicle; Projecting can include.

At last, in a vehicle guidance system including a plurality of robot devices, sensing the approach of the vehicle to project a warning image on the road surface, at least one other robot device of the plurality of robot devices It can include a first robot device for transmitting the access information and a second robot device for receiving the access information from the first robot device and projecting the detour path image.

According to any one of the above-described problem solving means of the present research, when a device meet the needs to guide the vehicle to the bypass path, the driver of the vehicle can timely determine the bypass path and move the vehicle to the bypass path. Further, it is possible to efficiently inform the driver of the vehicle that the road is in an unusable state.

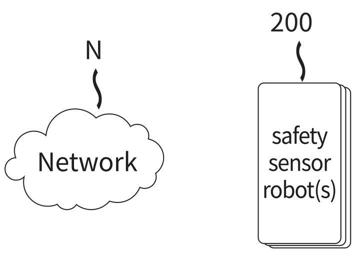

Figure 5. A vehicle guidance network according to robot-cloud-app communication.

2.2. User Research on Vehicle Guide System in the Road

To bypass the path on risk, the drivers have to be informed via personal information channel(e.g. mobile phone application) from vehicle guidance system network.

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Table 1. User observation research with interview.

	Goal	Observation Details
Observation	To identify inconvenience	Observe the behavioral flow
Interview	Contextual interviews to identify hidden inconveniences	Ask participants about the reason

3. Problem Definition

The "Vehicle Guidance Network" began with the need for classifying traffic jams, enabling AI driven problem solving so that it can make your commute feel good. This background starts with the serious traffic jam during rush hour which is critical for individual work efficiency. For both drivers and public transport users, safety sensor robot was designed to become guidance system for urban commuters. Requirements and needs for the guidance system can be extracted from a series of design processes.

3.1. Design Process for Preliminary Research

We observed and interviewed several commuters with the method of town-watching and IDI. The purpose of the observation is to identify the inconvenience caused by lack of information on the morning commute and to find ways to improve the information. We also observed the flow of behaviors that led to decision making in the participants' daily schedule. In addition, a contextual interview was conducted to find the hidden inconveniences that participants felt during the morning commute. We inquired about the reasons for the decision at the decision stage in the participant's daily schedule.

Through observation and context interviews, we were able to find five types of prints on our way to work. If there is an accident on the road, hold on until the insurance company gets the scene of the accident.

3.2. Total Design Process: From Design Research to Development and Implementation

Design process from planning to implementation is shown on Figure 7.

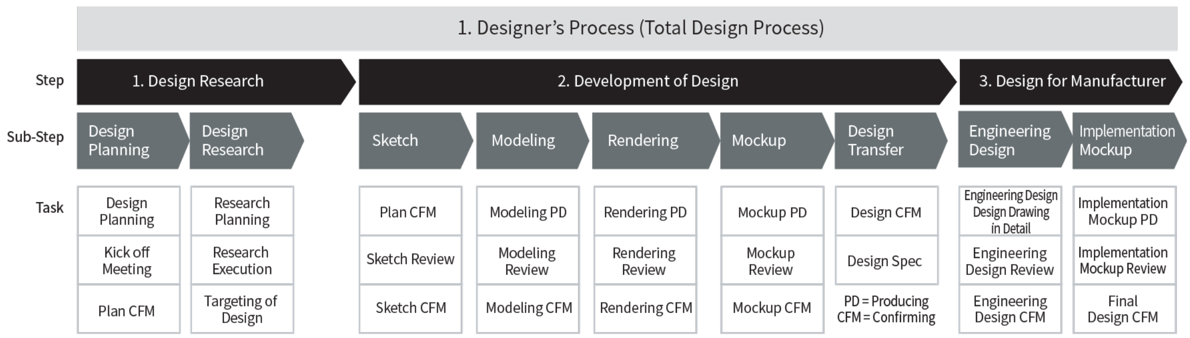

Figure 6. Total design process of access point robot in the highway/roads.

3.3. On-road-construction Site Studies for Collecting User Insight

In the context of the road construction work, maintaining sufficient distance to secure the field of view, ensuring visibility for beginner drivers and securing safety for construction workers were important needs. Previous research has shown consequent direction[2] like below :

- "Driving at night narrows your field of view. If you're driving on unlit roads, you'll only see the headlight range(100m up and 40m down), so it takes longer than daytime to find pedestrians and objects passing by."

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- "In night road construction, it is important to focus on road blocking issues due to the driver's neglect to look forward. Even the process of installing lavacons to focus attention is at risk."

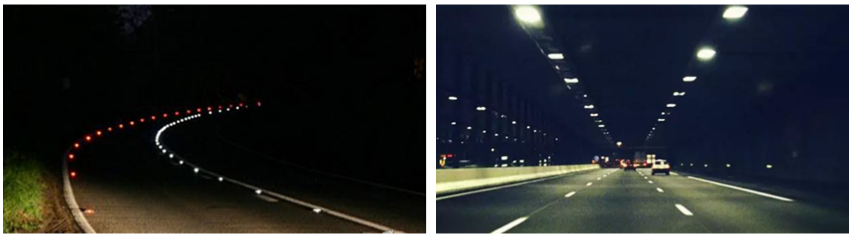

Figure 7. Road on work equipped with a series of lamps/lavacons.

4. Sensor Robot as Access Point

The above-mentioned background has technical information that the inventors possessed for the derivation of the present invention or acquired in the derivation process of the present invention. It is not necessarily a publicly known technique disclosed to the general public before the application of the present invention.

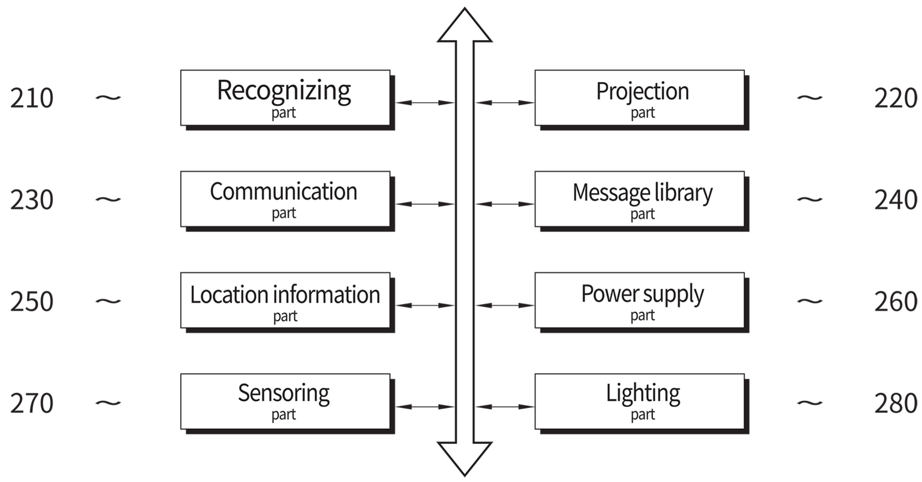

Figure 8. Block diagram of multiple functions(wireless access point and safety) in robot device.

According to Figure 8. representing block diagram showing an access point robot device, the robot body includes a recognizing part unit(210) in itself as the sensing detector. The robot device include a communication unit(230) and an image management unit(240) to be projected by the image projector(220).

4.1. Recognizing unit: For sensing vehicles

The recognition unit(210) can use an ultrasonic sensor to measure a distance to the vehicle approaching the robot device(200). The detector (210) may detect a vehicle approaching the robot apparatus (200) by measuring a distance from the vehicle approaching the robot apparatus (200) using an ultrasonic sensor. In addition, the recognition unit(210) can detect whether the vehicle is close to the robot device(200) by measuring a distance from the vehicle. It can detect the position of the vehicle near the installed robotic device. Because the detector includes a sensor for detecting a vehicle approaching the device. The sensor is equipped with a position-sensitive detector (PSD) sensor, a charge-coupled device(CCD) image sensor, an ultrasonic sensor, and an infrared (red) sensor to identify the presence and distance of the vehicle. In addition, any additional sensor capable of measuring the distance between objects is possible.

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For example, the identification unit(210) includes an ultrasonic sensor to a RADAR sensor, which uses a frequency band in a range of 20 KHz to 79 GHz to measure a distance from an object. In particular, the frequency band of the ultrasonic sensor used as the identification unit is not limited to the above-mentioned frequency band.

The recognition unit(210) periodically measures the distance between the robot device(200) and the vehicle, and when the measured distance between the vehicles is close to 600m and 500m, the vehicle approaches the robot device. The recognition unit(210) generates access information when a vehicle approaching the robot device(200) is detected. Here, the "access information" refers to information about the detection of the approach of the vehicle to the robot device(200), and includes at least one of the unique identification information of the robot. Device(200), distance information and approaching time information of the approaching vehicle.

4.2. Image projector: For alerting signals to vehicles

On the other hand, the robot device(200) includes an image projector(220). It project an image onto a road surface to which the vehicle approaches when the detector(210) detects the approach of the vehicle. Here, the 'image' can include a message for notifying a driver of the vehicle of a road condition or a detour route, and can be a video or an image. In addition, the 'image' can include a warning image including a message indicating the state of the road. For example, the "warning video" can include a message indicating the state of the road, such as "under construction" and "incident section." In addition, the 'image' can include a detour route image including a message indicating a detour route. For example, the 'detour route image' can include a message indicating a direction in which the vehicle should bypass, such as '->' and '»>'. In this case, the image to be projected can be set by the image manager(240) to be described later.

The image projector(220) can project an image on a road surface approaching the vehicle when the distance measured by the detector(210) is within a preset range. In addition, when the distance from the vehicle measured by the recognizing unit(210) using the ultrasonic sensor is within a preset range, the image can be projected onto the road surface to which the vehicle approaches. For example, when the distance from the vehicle is detected to be less than 500m, the image can be projected on the road surface approaching the vehicle. The image projector(220) can stop projecting an image when there is no vehicle approaching the robot device(200) by the sensor 210. Projecting images only when there is an approaching vehicle can improve battery usage efficiency.

The image projector(220) can include a light source unit inside the package. The light source unit can include at least one of a red laser diode, a green laser diode, and a blue laser diode. Here, the red laser diode is a light emitting device that emits red light, and the green laser diode is a light emitting device that emits green light. In addition, a blue laser diode is a light emitting element which emits blue light. In this case, the plurality of light emitting devices can emit color by combining at least one white beam. The light source unit can emit light generated in each of the laser diodes by a driving current applied from the power supply unit(260) to be described later according to a predetermined driving signal. The image projector(220) can project light emitted from the light source unit to the road surface approaching the vehicle. When the image projecting unit(220) projects an image on a road surface approaching the vehicle, the image projection unit(220) controls the projection angle to project the image to project the image on the road surface within the distance measured by the detection unit(210).

Here, the projection angle controller can control the projection angle to project the image to the front of the vehicle when the vehicle continuously approaches the robot device 200. The projection angle controller rotates at least a portion of the robot device(200) horizontally horizontally to the vertical axis relative to the road surface so that the image projector(220) can project an image on the road surface approaching the vehicle. You can. For example, the projection angle controller controls the image projector(220) to project an image on a road surface within a distance from the vehicle measured by the detector 210, based on a vertical axis with respect to the road surface. At least a part

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of the robot device(200) can be horizontally rotated to control the projection angle. For example, when the image projecting unit(220) projects an image in a direction opposite to an approaching vehicle, at least a part of the robot device(200) is rotated horizontally by 180 degrees to the left on the vertical axis of the road surface. The projection angle can be controlled to project an image in a vehicle direction.

4.3. Communication unit: For sharing information each other

The robot device includes a communication unit(230). The communicator(230) can transmit/receive data with the operator terminal(100) or other robot devices. In detail, the communication unit(230) operates a mobile communication module, a short range communication band. The mobile communication module can transmit/receive wireless data not only with operator terminal, but also with other robot devices on the network(N). The near field communication module is a module for near field communication, and includes Bluetooth, Radio wifi Direct(WFD) NFC universal serial bus (USB) internally equipped. The robot device can configure an ad-hoc network with the operator terminal(100) or at least one other robot device(200) through the communication unit(230) which transmit the access information generated by the recognizing unit(210) to the operator terminal(100) or other robot devices.

4.4. Message library part: Image manager stores at least one image.

Image manager(240) can include a module for managing an external storage device to manage at least one image stored in the external storage device. The external storage device can be a Universal Serial Bus (USB) memory. Accordingly, the image manager(240) can store at least one image in an external storage device.

Also, message library part(240) can set an image to be projected by the image projector(220) among at least one image. For example, the image to be projected by the image projector(220) can be set based on the image setting information received from the operator terminal(100) through the communication unit 230. Here, the image setting information includes identification information of an image to be projected according to unique identification information of each of the plurality of robot devices 200. The identification information of the image can be a combination of numbers or letters as information for distinguishing each of at least one or more images. For example, the image can include a warning image and a bypass path image. When identification information of an image including a 'under construction' message among warning images is received from the operator terminal(100) through the communication unit 230, the image management unit The image projector(220) can be configured to project a warning image including a 'under construction' message matching the identification information of the received image.

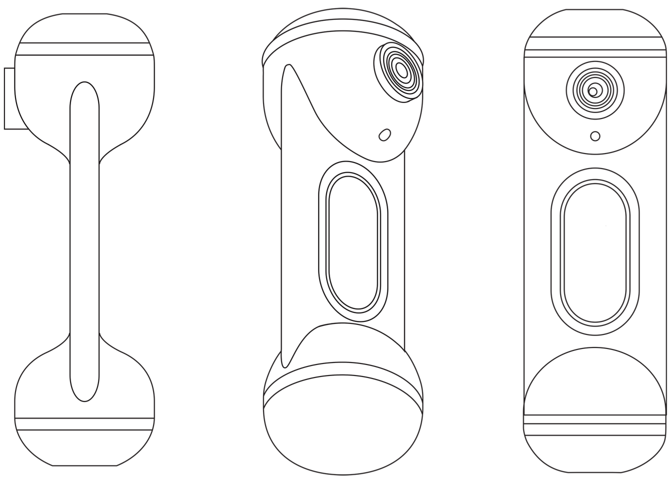

Figure 9. (a) Side view; (b) perspective view; (c) front view showing an individual robot device.

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4.5. Location information unit: Determined by GPS.

The image manager includes an input unit(interface) capable of receiving image setting information. When the operator inputs image setting information through the input unit, the image manager(240) can include one or more images. The image to be projected by the image projector(220) can be set. Also, the image manager(240) can set an image to be projected by the image projector(220) among at least one image based on the image setting information stored in the external storage device. The operation is based on the location information of the robot device(200) obtained by the location information unit(250).

For example, when it is determined that the robot device is within a preset range at the traffic accident point based on the acquired location information, the image manager(240) views the warning image to be projected by the image projector(220) in an 'accident occurrence'. 'Can be set to the image containing the message. For another example, the image manager(240) can determine that the robot device(200) is located closer to the vehicle approaching direction than the other robot devices(200) based on the acquired location information. Can be set to one of the warning images.

In addition, the location information unit(250) can acquire location information of the robot device 200. The location information can be longitude and latitude information. For example, the location information unit(250) can obtain location information from at least one of a global positioning system (GPS) and an outdoor positioning system (IPS). In addition, the location information of the robot device(200) can be obtained through a media access control (MAC) address of a connected wifi access point.

4.6. Power supply unit: Rechargeable and replaceable battery.

The robot device(200) includes a power supply unit 260. The power supply unit(260) can receive an external power source or an internal power source to supply power required for each component of the robot device 200. For its structure, the power supply unit(260) include a general rechargeable battery, which is built-in replaceable inside the robot.

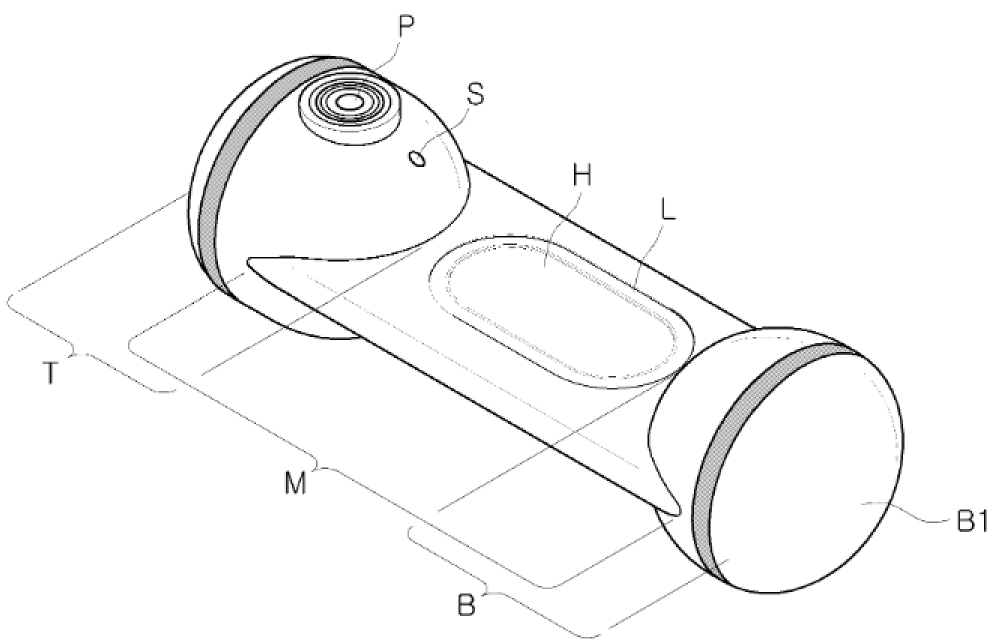

Figure 10. Distinguished unit sections in the robot device.

The robot include an upper end (T), the body (M), the lower end (B). The upper end portion T can be positioned above the body M and can include a projection module P for projecting an image. In

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addition, the upper end (T) can include a sensor module(S) for detecting the approach of the vehicle. Wherein the projection module(P) can be at least one of the configuration of the image projection unit(220) of the robot device 200, the detection sensor module(S) of the configuration of the detection unit(210) of the robot device(200) There can be at least one.

The body M can be positioned above the lower portion B, and can be positioned below the upper portion T to support the upper portion T, and can include a light emitting device L. The light emitting device L can include at least one of the components of the light emitting unit(280) of the robot device 200. In addition, the body M can include at least one hole H. Hole(H) can be formed in an elliptical shape long in the vertical direction from the center of the body (M). In this case, the hole H can function as a handle when the operator moves the robot device 200. In addition, the body (M) can include a control device for controlling each configuration of the robot device(200). For example, the control unit(230) can include at least one of the communication unit 230, the image manager 240, the location information unit 250, and the status checker 270.

The lower end portion B can have a hemispherical shape, but at least a portion thereof can include a bottom surface B1 abutting the road surface. For example, the lower end portion B can have a hemispherical shape, at least a portion of which is convex downward, and can include a bottom surface B1 at least a portion of which is in contact with the road surface. In addition, the lower portion (B) has a weight greater than the weight of the upper portion (T) and the body (M) so that it can move like portable machine, when the robot device(200) is installed even if the robot device(200) falls down You can stand. In addition, the lower end portion B can include a power supply unit(260) of the robot device(200).

4.7. State checker unit: The status information to be written in distributed databases.

First, the robot device(200) includes a state checking unit(270) which can check the operating state of each component of the robot device(200) to generate state information. Accordingly, the 'status information' refers to information on the operation state of each component of the robot device(200), the detection unit(210), the image projection unit(220), the communication unit(230), the image management unit(240), the location information unit information about an operation state of at least one of the(250) and the power supply unit(260) are included. Additionally, it includes information of the remaining battery charge of the power supply unit(260). Furthermore, the status checker(270) can cause the light emitter(280) to be described later to emit light so as to notify an operator when the remaining charge remaining battery is within a preset remaining range.

Second, the state checking unit(270) can check the communication state of at least one other robot device(230) through the communication unit 230. For example, the status checker(270) can store unique identification information of each of the plurality of robot devices(200) connected through a network, periodically check a communication state with at least one other robot device 230, and communicate with each other. Unique identification information of the impossible robot device(200) can be extracted. In this case, the status checker(270) can transmit the extracted unique identification information of the robot device that cannot be communicated to at least one of the operator terminal and at least one other robot device through the communication unit 230. In this case, the light emitting unit(280) described later can emit light.

Third, the status checker(270) can include a gyro sensor. Therefore, the state checking unit(270) can determine whether the robot device(200) has moved or fallen, based on the motion information of the robot device(200) detected by the gyro sensor. For example, if it is determined that the robot device(200) has fallen, the state check unit can generate state information indicating that the robot device(200) is inoperable, and the generated state information can be generated by the communication unit(230) by at least one other robot device.(200) or the operator terminal(100).

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4.8. Light emitting unit: LED.

The robot device includes a light emitting unit(280). The light emitter can include at least one light emitting device such as an LED. The LED illuminated light[15] can be emitted based on the status information generated by the status checker(270). Basically, the light emitting unit(280) can emit white light when the robot device(200) is operated, and the remaining battery charge level of the power supply unit(260) in the status check unit(270) is within a preset range. For example, it can emit red light. The light emitter(280) can emit green light when communication of at least one other robot device(200) becomes impossible. The color or on/off period of light emitted from the light emitter(280) based on the status information can be set by the operator terminal(100).

The vehicle guidance method according to the embodiment shown in Figure 11. includes steps that are processed in time series in the robot device(200) shown in Figures. 8 to 10. Therefore, even if omitted below, the above description of the robot device(200) shown in Figure 9. be applied to the vehicle induction method according to the embodiment shown in Figure. 11.

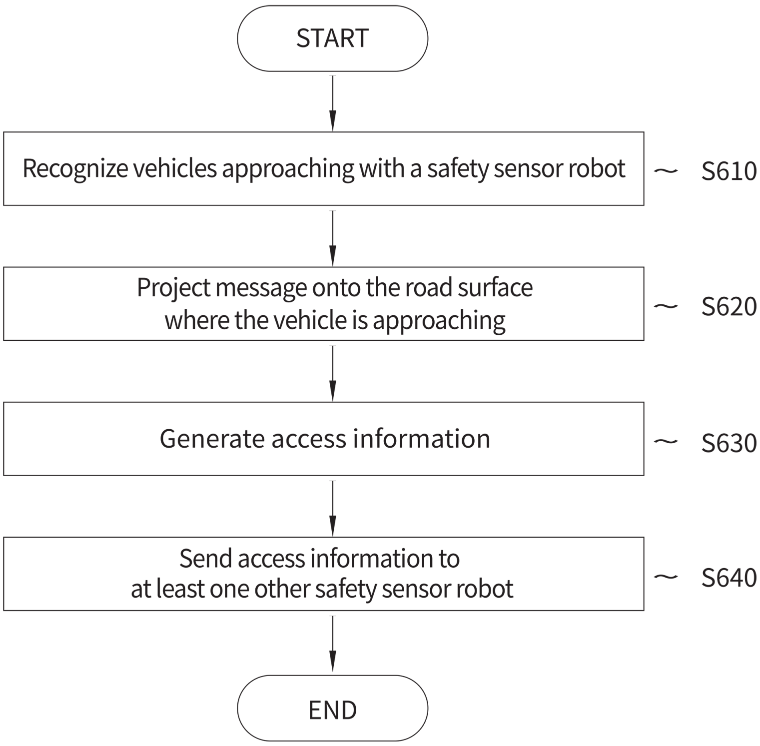

Figure 11. Vehicle induction: information generation from the robot device via access point function.

Figure 11 is a flowchart illustrating a vehicle induction method according to Figure 12 which is an exemplary view for explaining a method of inducing a vehicle by the robot device. The vehicle guidance method will be described with reference to Figs. 9 and 10.

The robot device(200) can detect the vehicle(300) approaching the robot device(200) (S610), then measure the distance D from the vehicle(300). For convenience of description, in the following and in Figure. 12, the distance D between the robot device(200) and the vehicle(300) is expressed perpendicularly to the vehicle while being parallel to the road surface. The distance D represents the robot device, which all possible distances are measured as the distance between the vehicles.

As such, the robot device(200) measuring the distance D from the vehicle(300) can detect whether the vehicle(300) approaches the robot device. For example, the robot device(200) periodically measures the distance D between the robot device(200) and the vehicle(300) and when the measured distance D

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between the vehicle(300) approaches, the vehicle 300. The approach to the robot device(200) can be detected.

On the other hand, when the robot device(200) detects that the vehicle(300) approaches the robot device 200, the robot device(200) can project an image on the road surface R to which the vehicle approaches (S620). The road surface R approached by the vehicle shown in Figure 12 is one embodiment of the road surface within a distance D from the vehicle 300. The image shown in Figure 12 is an embodiment of a warning image including a 'under construction' message. The safety robot device can :

- Project an image on the road surface R to which the vehicle approaches when the distance D with the vehicle(300) is within a preset range E. FIG. For example, the preset range E can be set to 500 m, and the robot device(200) can approach the vehicle when the distance D between the robot device(200) and the vehicle(300) is detected within 500 m. The image can be projected on the road surface R.
- Control the projection angle to project an image on the road surface R within the distance D from the vehicle 300, and project the image according to the projection angle.
- Generate access information when the vehicle(300) approaches the robot device(200) (S630).
- Transmit the access information generated by the at least one other robot device(200) (S640).

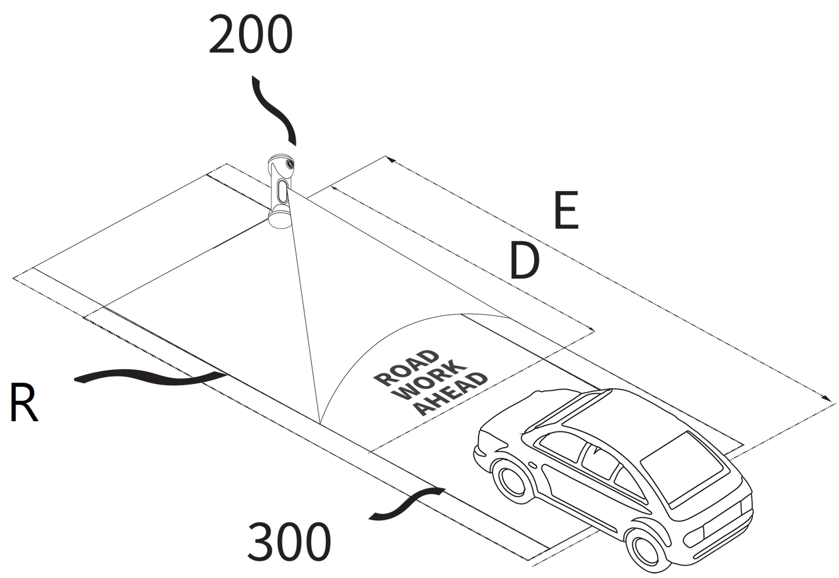

Figure 12. An exemplary view for explaining a vehicle guidance method.

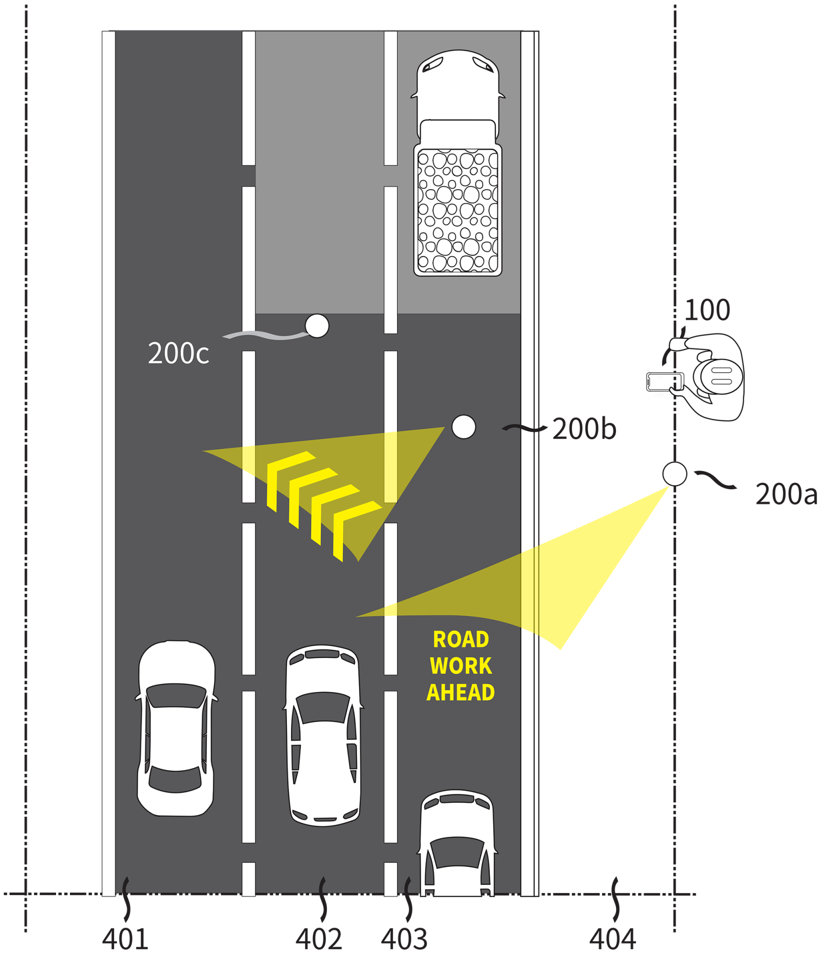

Figure 13. An exemplary views for explaining a vehicle guidance system.

Figures. 13 to 14 are exemplary views for explaining the vehicle guidance system, the vehicle guidance system includes an operator terminal(100), a first robot device 200a, a second robot device 200b, and a third robot device(200c). The vehicle guidance system can be operated on a road to a first lane(401), over second lane(402), or third lane(403) and shoulders(404), within its own safety. Each of the devices(200a, 200b, 200c) can be installed on or off the road.

The first robot device(200a) can detect the approach of the vehicle and project a warning image on the road surface. In addition, when the first robot device(200a) detects the approach of the vehicle, the first robot device(200a) generates access information and transfers the generated access information to at least one other robot device of the second robot device(200b) and the third robot device(200c). I can send it.

The second robot device(200b) can receive the access information from the first robot device(200a) and project the detour path image. In addition, when an error occurs in at least one of the first robot device(200a) and the second robot device 200b, the third robot device(200c) can replace the robot device in which the error has occurred. The third robot device(200c) can determine whether an error has occurred based on the state information received from the first robot device(200a) or the second robot device(200b). Alternatively, the third robot device(200c) can extract the unique identification information of the non-communicable robot device to identify the failing robot device based on the extracted unique identification information.

For example, based on the status information received from the first robot device(200a) or the second robot device(200b) to check whether the error occurs and the robot device that the error is

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confirmed as the second robot device(200b) In this case, the third robot device(200c) can replace the second robot device(200b) in which an error occurs. Also, for example, the third robot device(200c) can replace the second robot device(200b) in which an error occurs when the second robot device(200b) is identified as a robot device that cannot communicate.

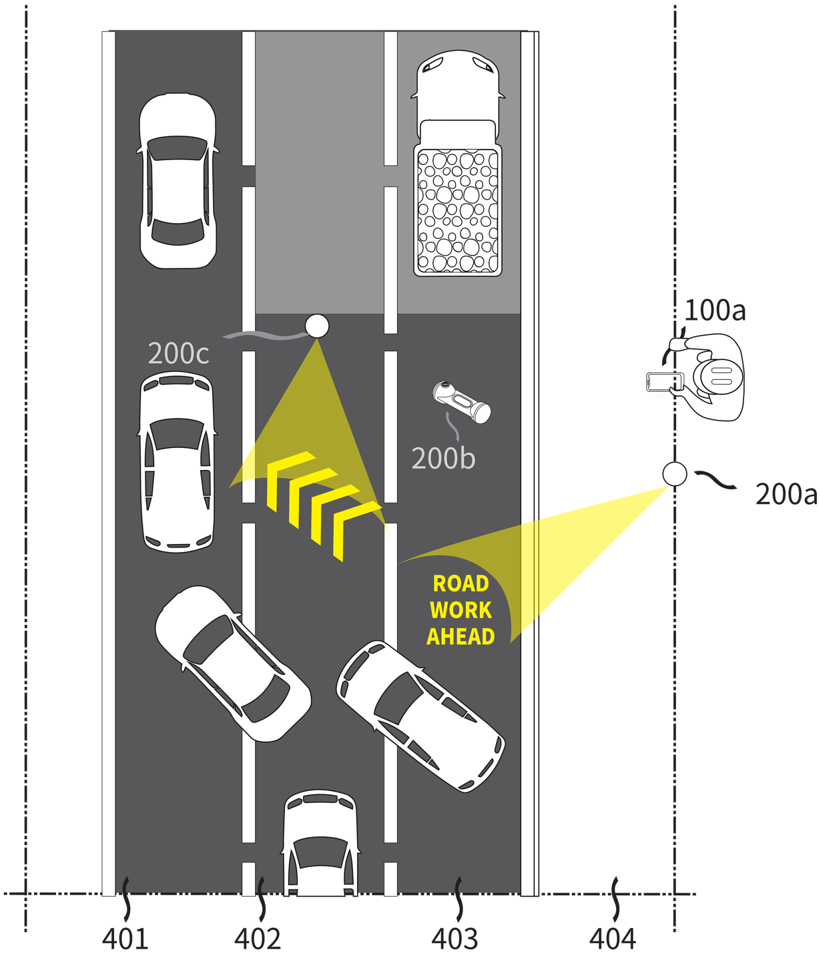

Figure 14. An exemplary views for explaining a vehicle guidance system (One robot damaged)

In accordance with the Figure 14, when the second robot device(200b) is damaged or fell down by a vehicle, the second robot device(200b) provides its status information to the first robot device(200a) and the third robot device(200c) through peer-to-peer communication. And at least one of the operator terminal(100), the status information can include unique identification information of the second robot device(200b). Also, image setting information, which is information about an image set by the fallen second robot device(200b) to be projected, can be transmitted to at least one of the first robot device(200a), the third robot device(200c), and the operator terminal(100).

In this case, for example, the operator terminal(100) displays the received status information and the operator checks the status information so that the third robot device(200c) can operate to replace the second robot device(200b). For another example, when the third robot device(200c) receives status information indicating that the third robot device(200c) has fallen or moved from the second robot device(200b), the second robot device(200b) matching the identification information of the robot device in which the error has occurred. can be identified as an error-prone robot device, and the second robot device(200b), which is an error-prone robot device, can be projected based on the image setting information received.

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When the second robot device(200b) is in a emergency state where communication is impossible, the third robot device(200c) extracts unique identification information of the second robot device(200b) in a state where communication is impossible, The image set in the second robot device(200b) can be projected from the image setting information based on the unique identification information of the second robot device(200b). At this time, the image setting information includes identification information of the image to be projected according to the unique identification information of each of the first robot device(200a), the second robot device(200b), and the third robot device(200c). The third one(200c) projects an image in which at least one image stored in the image manager(240) matches identification information of the image.

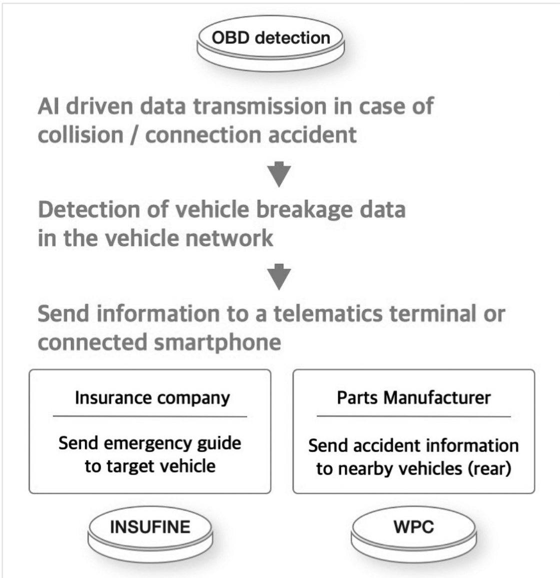

Figure 15. Data flow of a vehicle guidance system, from sensor robots to in-vehicle network.

On the other hand, along with the robot device, the vehicle guidance system and method using this example are applied to road construction and traffic accidents. Even if it is necessary to guide the vehicle through the bypass route of the present invention, the technical idea is applicable. A vehicle guidance method according to the embodiment described with reference to FIG. 11. It may also be implemented in the form of a recording medium including instructions executable by a computer, such as a program module instance or example.

Computer-readable media can include computer storage/communications media or volatile/nonvolatile, removable/non-removable media. It is implemented in any method or technology for storing information, such as computer readable instructions, data structures, program modules or other data. It works on modulated data signals(such as carrier waves) or other transmission mechanisms and includes any information delivery medium.

In addition, the vehicle guidance method may be implemented as a computer program(or computer program product) containing instructions executable by a computer. The computer program includes programmable machine instructions that are processed by a processor and can be implemented in a high-level programming language, an object-oriented programming language, an assembly language, or a machine language. The computer program can also be recorded on a tangible computer-readable medium(for example, memory, magnetic/optical media, or solid-state drive, etc.).

Therefore, the vehicle guidance method according to the preliminary study can be realized by executing a computer program as described above by a computing device. The computing device may include a processor, a memory, a storage device, a high-speed interface connected to the memory and a high-speed expansion port, and at least a portion of a low-speed interface connected to the low-speed

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bus and the storage device. Each of these components is interconnected using various buses and can be mounted on a universal motherboard or installed in a suitable manner.

Here, the processor can process instructions within the computing device, such as displaying graphical information for providing a graphical user interface (GUI) on an external input, output device (such as a display connected to a high-speed interface). Instructions are stored in memory or memory. In other embodiments, multiple processors and/or multiple buses may be used with appropriate multiple memories and memory types. The processor may also be implemented as a chipset composed of chips including a plurality of independent analog and/or digital processors.

The memory also stores information in the computing device. In one example, the memory may include a volatile memory unit or a collection thereof. As another example, the memory may consist of a non-volatile memory unit or a collection thereof. The memory may also be another form of computer-readable medium, such as a magnetic or optical disk.

The foregoing description of the present invention is intended to be illustrative, and those skilled in the art will understand that the present invention can be easily modified in other specific forms without changing the technical spirit or basic features of the present invention. will. Therefore, it should be understood that the above-mentioned embodiments are illustrative and not restrictive in all aspects. For example, each component described as a single type can be implemented in a distributed manner, and similarly, components described as distributed can be implemented in a combined form.

The design of the sensor robot first focused on ease of installation and operation. In its operation, swarm robotic technology communication becomes active as a public device status report. We introduced safety lighting systems and interfaces to interoperate robots and gather information together. Preventive design is one way to solve problems. Based on the cooperation of relevant agencies, we will work in the same external environment as the actual highway, and implement the verification method by implementing and testing the lighting that indicates a safe bypass. It shows examples of finding emergency but undisclosed niche markets through design methods such as problem identification and field demand identification.

5. Mobile App Development

For commuting users of the system, we introduced the mobile application to support decision making. According to the insightful user study results, we categorized three functional approaches below[00]:

- "Different way to work"
- "Wise way to work"
- "Refresh way to work"

5.1. Different way to work

5.1.1. Data collecting for alternative pathway to guide user

First requirement is personalized experience during the trip. While using the "Different way to work" function, user can get guide of the best route using big data (car accidents, traffic situation, rest area, drowsiness rest area) from collected data such as highway information API.

5.1.2. Database design

Personalized information service for user is first aim to build database for different way to work. On the other hand, authority can control congested traffic from decentralized resources from various APIs below:

- Traffic volume by time
- RISK[]. TRIP[] - dangerous driving statistics
- VDS_LCS[] - daily traffic volume for every period, in specific operating area

Table 2 shows the database construction of "Different way to work".

Table 2. Data type and causal inference in DB of "Different way to work".

Index(type)	Traffic Volume	RISK	TRIP	VDS_LCS
Data Type Causal Inference	Data Instrument	Data Instrument	Data Instrument	Data Co-founder

5.1.3. Display design result of app function

Display for different way to work emphasized new experience component to user to attract commuter to select the alternative way as shown on Figure 0.

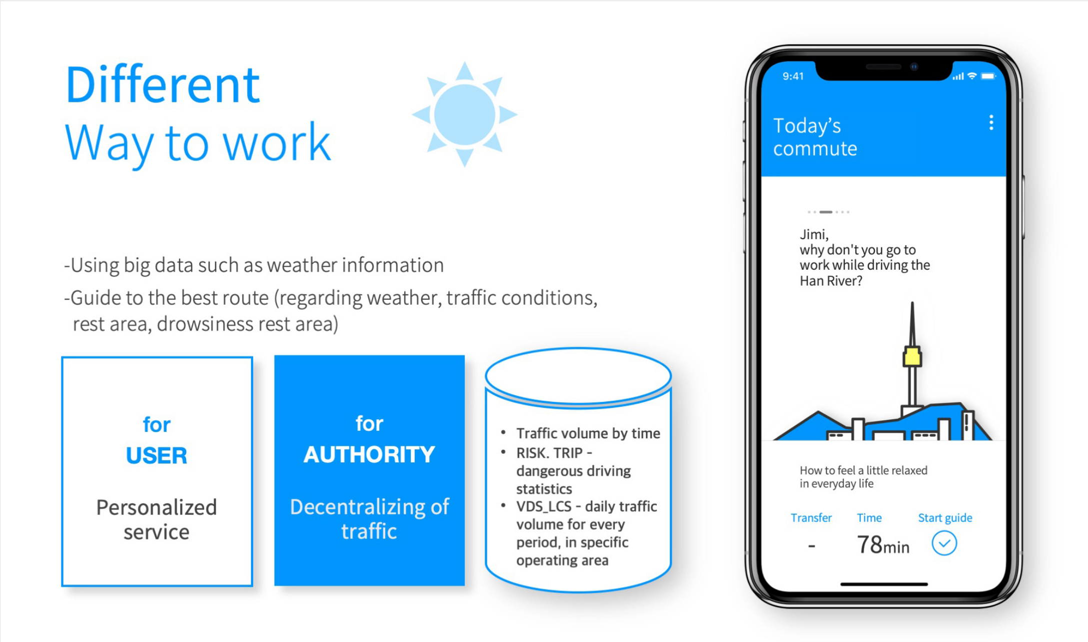

Figure 16. Display of "Different way to work".

This application function suggests commuters a different way which they used to pass. Operation of the app to find the optimal route using big data APIs(weather, current traffic conditions, rest stops, shelters) according to user sleep time and custom arrival time settings, daily weather information and fine dust information. Driver(user) generated features are mainly focused on understanding individual patterns and operating as a service tailored to the individual. The application will also make linked products like:

- Personalized service for rush hour pass to work
- Decentralized traffic which is congested
- Traffic measurement and notification by time

5.2. Wise way to work

5.2.1. Data collecting for alternative pathway to guide user

Second requirement is personalized arrival time. While using the "Wise way to work" function, user can get guide of the best route using big data (weather, , traffic jam, delay zone, black ice, and so forth) from collected data such as weather information API.

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5.2.2. Database design

Personalized information service for user is first aim to build database for different way to work. On the other hand, authority can control congested traffic from decentralized resources from various APIs below:

- Current traffic
- Monthly weather forecast
- Weather observation of specific area around road, from Korean government open APIs
- Dust - PM10, PM2.5 from "Air Korea[]"

Table 3 shows the database construction of "Wise way to work".

Table 3. Data type and causal inference in DB of "Wise way to work".

Index(type)	Current traffic	Monthly W.forecast	W.OBS.area	(Dust) PM10	(Dust) PM2.5
Data Type	Data	Data	Data	Data	Data
Causal Inference	Instrument	Co-founder	Co-founder	Co-founder	Co-founder

5.2.3. Display design result of app function

Display for wise way to work emphasized new experience component to user to attract commuter to select the alternative way as shown on Figure 17.

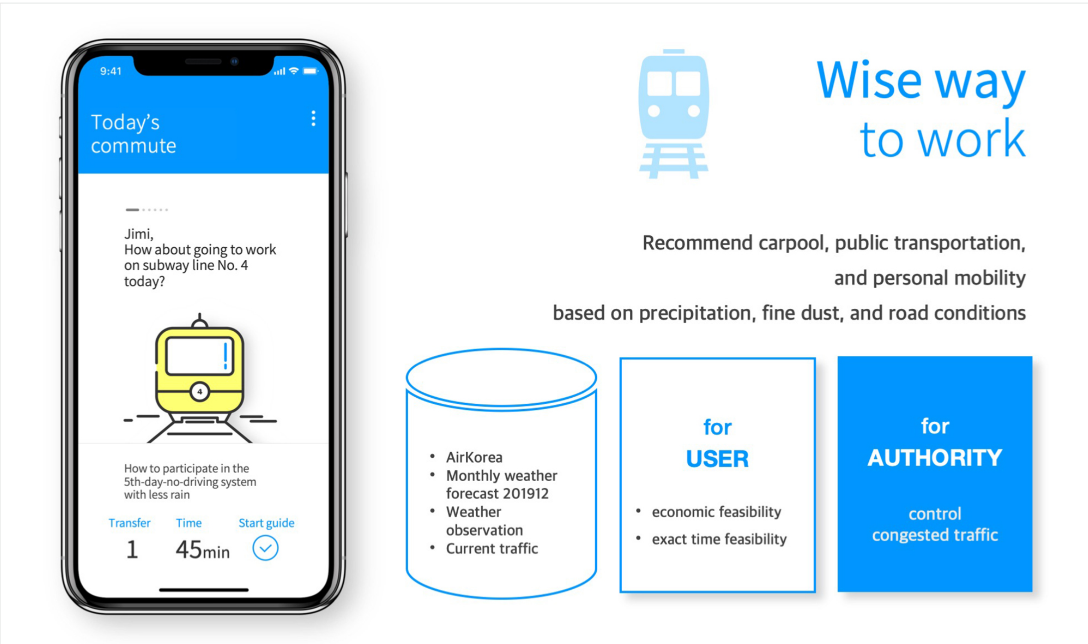

Figure 17. Display of "Wise way to work".

Along with weather, road condition is important fact for users to decide which way to drive on every route. Depending on precipitation, fine dust, road conditions, etc., car pools, public transportation, and personal mobility recommendations can be provided via app. The function suggests the better commute(ex: only today, from home, to work) information. For instance, spread by public transportation, load on road can be decreased while temporary "black ice" appeared in the pathway.

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5.3. Refresh way to work

5.3.1. Data collecting for alternative pathway to guide user

Third requirement is personalized enjoyable journey. While using the "Refresh way to work" function, user can get guide of the best route using big data (event, travelers' site, density on the bridge) from collected data such as local information API.

5.3.2. Database design

Despite both safety and time reduction are important for user in "Refresh way to work", authority can assure quick clear of accident on the road resourced from clouded AP robots and from various open APIs below:

- VDS by lane
- Speed by direction
- Local route speed by hour

Table 4 shows the database construction of "Refresh way to work".

Table 4. Data type and causal inference in DB of "Refresh way to work".

Index(type)	VDS by lane	Speed by direction	Local route speed by hour
Data Type Causal Inference	Data Co-founder	Data Instrument	Data Risk factor
Pseudo(SQL) code			
SELECT ———— DATE_FORMAT(STR_TO_DATE(YMD, 'Ymd'),'Y-m-d') as YMD, TRAFFIC FROM VDS_TRAFFIC_MSUM ———— WHERE YMD >= '20191201' ———— WHERE YMD <= '20191231'			

5.3.3. Display design result of app function

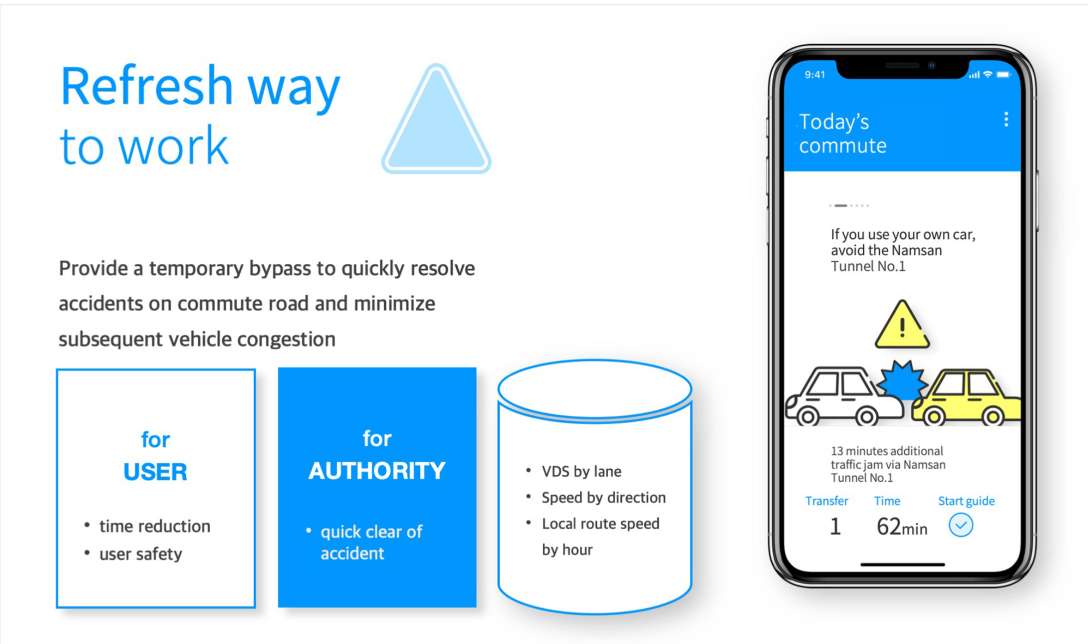

Figure 18. Display of "Refresh way to work".

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Display for refresh way to work emphasized new experience component to user to attract commuter to select the alternative way as shown on Figure 18.

5.4. Summary

The AI-based value creation approached by this system leverages data from road traffic environments and map information systems to help coordinate overall traffic. Representing three way like: (1)"Different way to work", (2)"Wise way to work", (3)"Refresh way to work"[16] pursue to instill a happy memory of commuting. To all users who commute by highway/roads, the application will contribute to creating a balanced condition through stable routine.

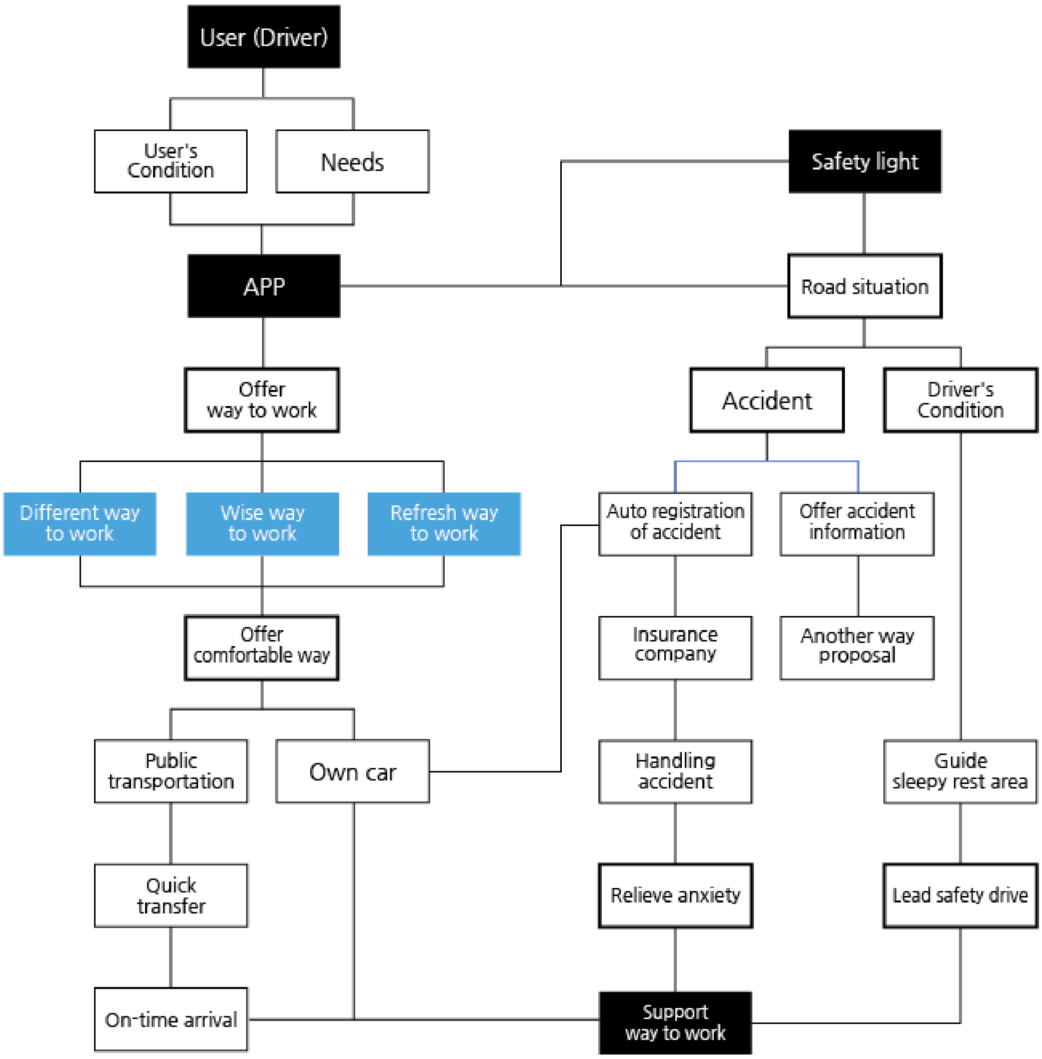

Figure 19. Information architecture of table for way to work.[16]

6. Discussion

We discussed firstly on benchmark of "RITIS" to individual users as well as public data center for informing transportation. Multiple safety sensor robots working in the middle of highway/roads can show their recognition with robot-to-robot communication in ad-hoc network. Additional function of projecting messages to a specific dangerous vehicle is available with its supervised learning in real time. According to the signals from sensor robots, real-time data from APIs, customized recommendation for users are mixed to provide for users. We resulted in three types of function module from the perspective of:

- Causal inference to DB
- DB to IA(information architecture)
- IA to layout
- Layout to display
- Display to state-transition in the mobile application of user.

Figure 20. Convergence scenario from safety sensor robot to inform mobile application.[16]

7. Conclusions

We in the study, recognizes the need to build a customized service system that ensures driver safety and resolves inconveniences on the road and suggests possible directions and answers. The driver(user) can work through a safe and convenient user-oriented service system, and the driver can freely choose the desired pattern. The solution approached in this study is to guide the driver's vehicle on a safe path with low risk of accident. It aims to integrate safety and efficiency with convenient apps through a terminal designed through a proven system based on big data. The system focuses on the safety of the user and expects the safety and convenience of the method of use. To promote local information sharing in the highway/roads, An access point and safety lighting device works like interlinked robot which communicates with each other.

8. Patents

This research is registered in patent application: Hong, S.; Eune, J.; Lee, M.; etc. (2017). Safety device for guiding vehicle to detour route, vehicle guidance method using same, and vehicle guidance system using same. International patent #WO2017065329A1.

Author Contributions: Conceptualization, M.L. and H.J.; formal analysis, J.K.; investigation, M.L., J.K. and J.E.; methodology, I.H.; project administration, M.L., J.K and J.E.; resources, M.L., T.J., J.W., E.J. and S.G.; software, J.K.; supervision, C.K. and J.E.; visualization, E.J. and S.J.; writing – original draft, M.L. and J.W.; writing – review & editing, C.K. and J.E.

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

D	Distance (between the sensor robot and approaching vehicle)
H	Hole
L	Light emitting device
P	Projection module
R	Road surface
S	Sensor module (the recognition unit=recognizing unit=the identification unit=the detection unit=the detector)
T	Top (the upper end)
M	Middle (the body)
B	Bottom (the lower end)
API	Application Program Interface
VGN	vehicle guidance network
IA	information architecture

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