# FUNDAMENTAL SOLUTION OF HUMAN ERRORS: INVENTION OF 'INTELLECTUAL CONFIRMATION OF POINTS AND ANSWER VOICE RECOGNITION SYSTEM'

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## 1. BACKGROUND

The number of cases which mainly cause of major disasters, identified as human errors are increasing. While industrial systems are becoming more complex and faster, worker's information processing and performance capabilities are hard to catch up and accommodate them. Human errors define all human being's inability(including forbidden acts) to perform specified action within specified accuracy, order or time limit and also as a result, the equipment may be damage or the schedule work may be interrupted. Such human errors are major cause of various safety accidents, and also fundamental cause of railway and train accidents.

According to Korea Transportation Safety Authority's annual report on railway safety in 2020, in recent 5 years(2016~2020), There are several factors to cause train accidents, among the factors; technical factors(11 cases, 41%), human factors(11cases, 41%), external factors(3cases, 11%), other matters(2 cases, 7%), human factors are the main reasons to cause train accidents(Table 1). Looking at the causing factors of train accidents over the past 5 years, the human factors have been occurred continuously in every year. And specifically among human factors in total(11 cases), 6 cases were caused by conductor's speeding and signal violations and accounting for 54.5% of the total number of train accidents(Table 2).

Table 1. Factors to cause train accidents('16~'20)

| Factor \ Year | '16 | '17 | '18 | '19 | '20 | Total | Ratio |
|---|---|---|---|---|---|---|---|
| Total | 9 | 4 | 4 | 6 | 4 | 27 | 100% |
| Technical | 7 | - | - | 2 | 2 | 11 | 40.7% |
| Human | 1 | 4 | 3 | 2 | 1 | 11 | 40.7% |
| External | 1 | - | 1 | 1 | - | 3 | 11.1% |
| other | - | - | - | 1 | 1 | 2 | 7.4% |

Table 2. Human Factors to cause train accidents('16~'20)

| Factor | Year | '16 | '17 | '18 | '19 | '20 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|
| Human Factors | total | 7 | - | - | 2 | 2 | 11 | 100% |
| | Conductor (speeding, signal violation) | 3 | - | - | 2 | 1 | 6 | 54.5% |
| | Construction | 1 | - | - | - | - | 1 | 9.1% |
| | controller | 1 | - | - | - | - | 1 | 9.1% |
| | Insufficient maintenance | 2 | - | - | - | 1 | 3 | 27.3% |

In Seoul Metro work site, in recent 5 years(2017~2021), there were 131 cases of accidents/errors caused by human errors. Among 131 cases, 83 cases(63%) caused by human errors in the train operation field and It took up a large proportion in total, compared to other fields(Table 3) and (Figure 1). Among 83cases happened in the train operation field, the 61 cases(72%) are caused by non-execution of "confirmation of points and answer"; mishandling doors/PSD and overpass signals, etc(Table 4).

Table 3. Human errors to cause train accidents/errors, Seoul Metro('17~'21)

| Year | Total | Customer service | Train operation | Rolling stock | Technical parts | | | | | | | | | | Control | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Electric | Telecommunication | Track | Signal | Mechanical | Electronic | Architecture | Civil Engineering | E/S, E/V | PSD | | |
| Total | 131 | 2 | 83 | 10 | 7 | 0 | 4 | 4 | 4 | 1 | 5 | 4 | 1 | 2 | 2 | 2 |
| '17 | 35 | 1 | 22 | 4 | 1 | 0 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| '18 | 35 | 0 | 23 | 2 | 4 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| '19 | 24 | 1 | 14 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 1 |
| '20 | 21 | 0 | 14 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 |
| '21(half) | 16 | 0 | 10 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

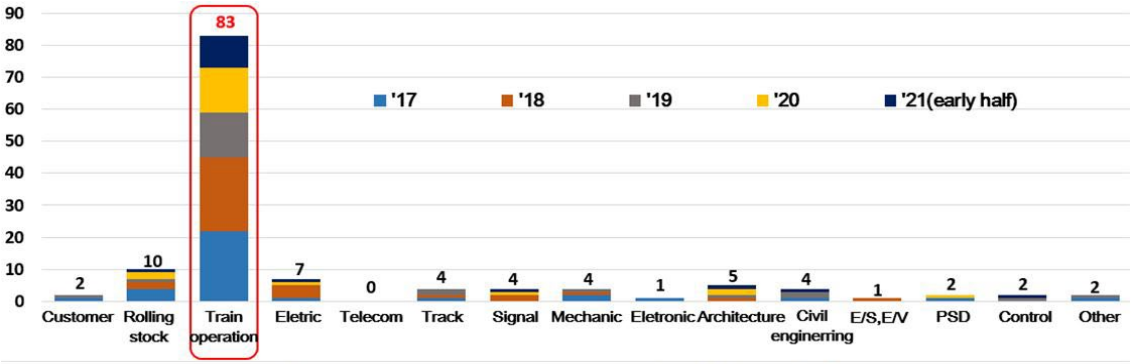


Figure 1. Human errors in every parts, Seoul Metro('17~'21)

Table 4. Human error type in Train operation, Seoul Metro('17~'21)

| Human error Type | | Negligence of confirmation | Noncompliance with regulation | Mishandling of device | Lack of expertise |
|---|---|---|---|---|---|
| total | 83 | 61 | 4 | 15 | 3 |
| Train operation | | • mishandling door/PSD, 30<br>• Overpass signals, 10<br>• non stop pass, 3<br>• wrong spot at platform, 3<br>• careless handling of trains, 3<br>• not check of left passengers, 2<br>• forget of last stop, 1<br>• run of parked car, 4<br>• early star of first car, 2<br>• passenger's entrapment, 3 | • unauthorized entry into tracks. 1<br>• inability to operate, 1<br>• noncompliance with track entrance regulation, 1<br>• delay in departure, 1 | • handling opposite door, 4<br>• mishandling of device, 2<br>• careless handling of device, 8<br>• discharge of parked car, 1 | • insufficient initial response to car's failure, 2<br>• careless handling of trains, 1 |

As it is, Human factors(errors) of the train drivers account for a large proportion of the total accidents and errors. And it can cause massive property damages along with passenger safety accidents. The amount of property damages('16~'20) is expected to reach 5.5million us dollar.(Annual report on railway safety in 2020, Korea Transportation Safety Authority, 2020)

Therefore, it is definitely needed to invent the system for helping train drivers recognize themselves if they fail to perform "confirmation of points and answer", to prevent human errors causing train accidents.

## 2. OBJECTIVE

This study aimed to explain the operating principles and functions of 'Intellectual confirmation of points and answer voice recognition system' step by step. 'Intellectual confirmation of points and answer voice recognition system' is inducing the voluntary implementaion of train driver's "confirmation of points and answer" act to make sure train stops in the right spot at the platform, opening/closing of the door/PSD, and the passenger's getting on/off at the platform.

## 3. METHODS

### 3.1 General operating principle

When the train arrives at platform, the system recognizes the train through 'Stop signal transmission device' and 'Stop recognition device'. 'Alarm device' activates through a wake-up signal in dormant state and perform each step for inducing train driver's "confirmation of points and answer". then performs data process of train driver's voice signal through the microphone. And then analyze the train driver's voice input signal corresponding to the stop of the train at platform, car doors/PSD opening, passenger's getting on/off. As the each steps of train driver's "confirmation of points and answer" is completed through the system, the 'Alarm device' goes into a dormant state(Figure 2).

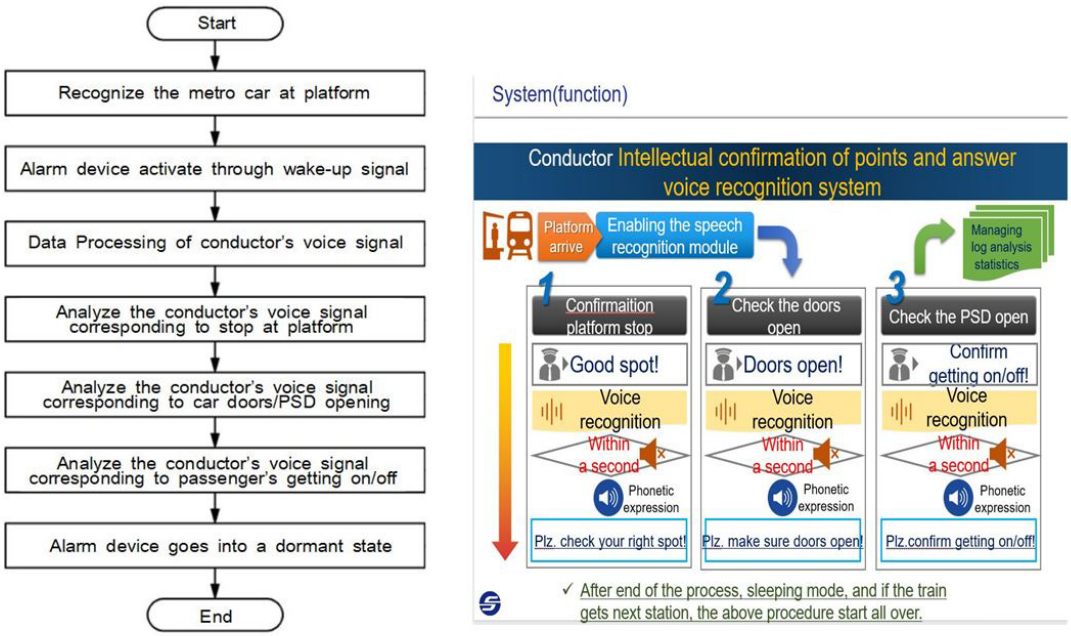


Figure 2. Flow diagram of operating principle(Intellectual confirmation of points and answer voice recognition system)

### 3.2 Detailed description of the System operation

The system is consist of 'Stop signal transmission device', 'Stop recognition device', 'Alarm device' (Figure 3). Inside of the train driver's car, the data terminal is placed or mounted. The data terminal is the configuration as a tool for utilizing the system, it can be implemented in various ways; desktop, notebook, smartphone, etc. In case of smartphone as a teminal, after installing a specific application, the system can be activated by running it. Screen can be desplayed through the data terminal in train driver's car. And

it is desirable that a microphone is built in or needs to connect an external microphone so that the train driver's voice signal can be recognizable.

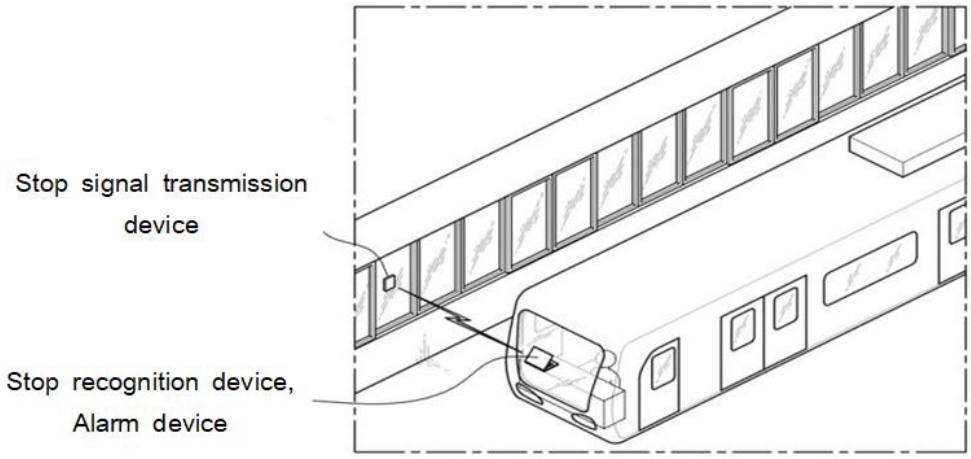


Figure 3. Intellectual confirmation of points and answer voice recognition system installation

'Stop signal transmission device' is set up at platform and communicates with the 'Stop recognition device' through wired or wiredless network(Figure 3). The 'Stop signal transmission device' can recognize the train arrives at the platform. This 'Stop signal transmission device' is used by a RFID(Radio-Frequency Identification) tag, it can be mounted on a track or any structure at platform. And also using a Beacon or wireless router mounted on PSD or any structure at platform.

'Stop recognition device' is set up in the train driver's car(ex.in the data terminal) (Figure 3) of the train, when the signal is received from the 'Stop signal transmission device', it transmits the wake-up signal to the 'Alarm device'. When the 'Stop recognition device' receive the wire/wireless signal from 'Stop signal transmission device, by transmitting a wake-up signal to an 'Alarm device' in dormant state, the 'Alarm device' initiate the inducing operation of train driver's "confirmation of points and answer".

'Alarm device' is a configuration that receive and analyzes the train driver's voice signal throughout the termianl and induce the train driver's procedure of "confirmation of points and answer". For this purpose, the 'Alarm device' is consist of 'Wake-up module', 'Voice processing module', 'Voice recognition module' and 'Alarming module' (Figure 4).

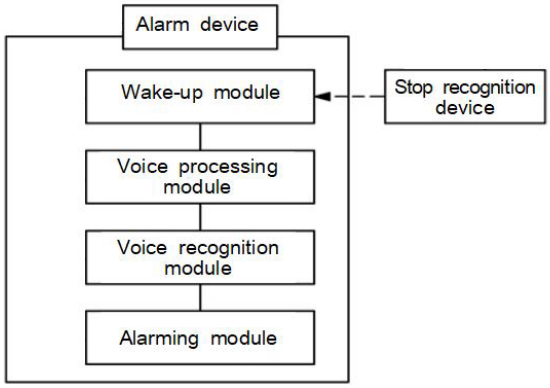


Figure 4. Flow diagram of Alarm device

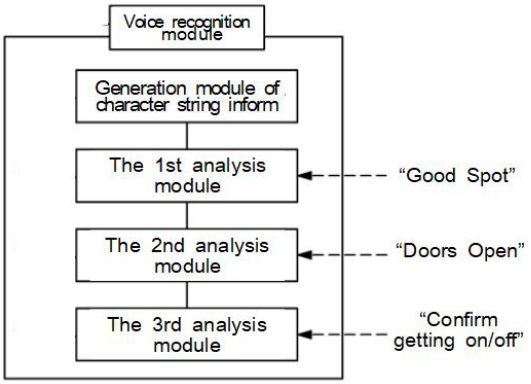


Figure 5. Flow diagram of Voice recognition module

The ‘Wake-up module’ receives a wake-up signal from the ‘Stop recognition device’ to activate the ‘Alarm device’. The ‘Voice processing module’ can pre-processes or post-processes(as necessary) a train driver’s voice signal input through a mcirophone. By including the Noise Suppression(NS)function, it is possible to eliminate noise contained in the train driver’s voice signal input. It can also include End-Point-Detect(EPD) for detecting the end point of the train driver’s voice signal. And it can also include Automatic Gain Control(AGC), so the volume of the train driver’s input may be adjusted to be suitable for recognizing and processing the train driver’s voice signal. As it is, the ‘Voice processing module’ is activated before ‘Voice recognition module’ performs analyzing the input signal, or when the voice recognition module recognizes train driver’s inappropriate voice input.

The ‘voice recognition module’ is a module that recognizes a voice signal corresponding to the train driver’s continuous “confirmation of points and answer”(Figure 5). This ‘voice recognition module’ allows the terminal to receive the train driver’s voice signal through the microphone and extract a character string from the corresponding voice signal and generate character string information for analyzing. The ‘Voice recognition module’ can also include Natural Language Processing(NLP) for obtaining intentional information of natural language.

The ‘voice recognition module’ can include ‘Generation module of character string inforamtion’, ‘1st and 2nd analysis module’. ‘Generation module of character string’ generates the character string inforamtion corresponding to train driver’s input signal. This ‘Generation module of character string’ can extract the charater string throgh Google’s Speech To Text(STT) way. The ‘1st analysis module’ can recognize and analyze voice signal for the train driver’s stopping of the metro platform by letter digit. For example, when the train driver shout “Jung Cha Yang Ho” at the platform, it means “Good Spot” in korean, through terminal mounted in train driver’s car, The ‘1st analysis module’ can recognize and analyze the charater string information or voice input. In case of not receving a voice signal within a pre-set time or not recognizing the voice signal corresponding to the stop of the train, according to the ‘1st alarming module’, it may occur a warning sound(Figure 6). Even the train driver’s voice signal(or corresponding string information) corresponds to at least one or two digits korean characters out of the four characters; “Jung”, “Cha” ,“Yang”, “Ho”, ‘The 1st analysis module’ can recognize the voice signal right way. Through this method, errors due to inaccurate pronunciation and differences in intonation by the train drivers can be prevented as much as possible. This may by applied to all of ‘The 2nd and 3rd analysis module’.

‘The 2nd analysis module’ can recognize and analyzes the train driver’s voice input on opening the car’s door/PSD. For example, when the train driver shout “Doors open” through terminal, it can recognize and analyze the charater string information or voice input. In case of not receving a voice signal within a pre-set time or not recognizing the voice signal corresponding to the stop of the train, according to ‘The 2nd alarming module’, it may occur a warning sound(Figure 6). It is desirable that ‘The 2nd analysis module’ is driven on the primise that a voice signal for stopping the metro platform or a corresponding character string information is received through ‘The 1st analysis module’.

‘The 3rd analysis module’ can recognize and analyzes the train driver’s voice input signal on passenger’s getting on/off. For example, when the train driver shout “Confirm getting on/off” through the terminal, it can recognize and analyze the charater string information or voice input. In case of not receving a voice signal within a preset time or

not recognizing the voice signal corresponding to the passenger's getting on/off, according to 'The 3rd alarming module', it may occur a warning sound(Figure 6). It is desirable that 'The 3rd analysis module' is driven on the primise that a voice signal for car doors/PSD opening or a corresponding character string information is received through 'The 2nd analysis module'. If the passenger's getting on/off confirmaition is completed through 'The 3rd analysis module', the 'Alarm module' returns to the dormat state. 'The 3rd analysis module' is on the premise of 'The 1st/2nd analysis module's operation. Throughout these 'Voice recognition module', it can induce the train driver's "confirmation of points and answer"; "Good spot", "Doors open", "Confirm of passenger's getting on/off".

As of this whole procedure, it is possible to support and manage the voluntary implementation of train driver's "confirmation of points and answer" and it has the advantage of preventing the possibility of human errors and safety accidents in advance.

The 'Alarming module' generates an alarm for the train drivers recognize themselves, if the analysis result of the voice signal input through the 'Voice recognition module' does not correspond to the appropriate voice signal, during the performing of train driver's "confirmation of points and answer". 'The 1st alarming module' occurs an alarming sound when it can't recognize and analyzes voice signal for the train driver's stopping of the metro plarform. For example, In case of not receving a voice signal corresponding to the stop of the train within a preset time, it may occur a "Plz. Check your right spot" alarming sound. 'The 2nd alarming module' occurs an alarming sound when it can't recognize and analyzes voice signal for car doors/PSD opening. In case of not receving a voice signal corresponding to the car doors/PSD opening within a preset time, it may occur a "Plz. Make sure doors open" alarming sound. 'The 3rd alarming module' occurs an alarming sound when it can't recognize and analyzes voice signal for passenger's getting on/off. In case of not receving a voice signal corresponding to the passenger's getting on/off within a preset time, it may occur a "Plz. Confirm getting on/off" alarming sound.

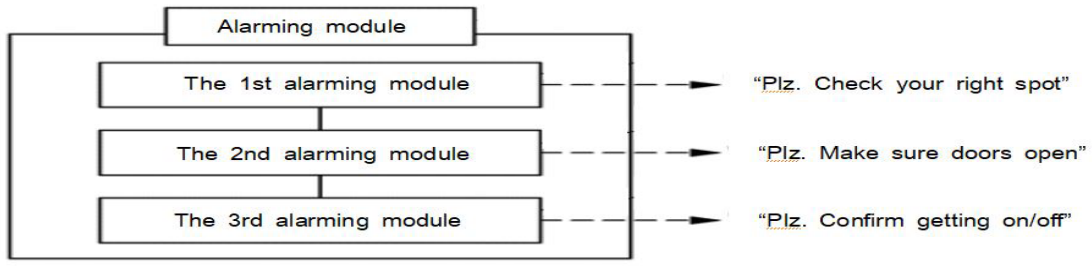


Figure 6. Flow diagram of Alarming module

## 4. RESULTS

As above, it describes the 'Intellectual confirmation of points and answer voice recognition system's operating principles and functions. The system is consist of 3 devices('Stop signal transmission device', 'Stop recognition device', 'Alarm device'). and when the train gets arrived at the platform, 'Stop recognition device' recognize the train, then 'Alarm device' activates through receiving a wake-up signal in dormant state and performs for inducing train driver's "confirmation of points and answer". As the each steps of train driver's "confirmation of points and answer" is completed through the system, the 'Alarm device' goes into a dormant state(Figure 7). Inventing of 'Intellectual

confirmation of points and answer voice recognition system' helps to prevent happening of railway and train accidents.

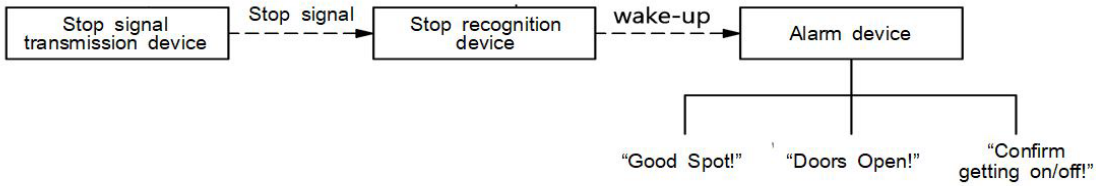


Figure 7. Flow diagram of the system's general operating principle and function

In another study(Effect Analysis of Railway Accident due to Recognition for a cheer response, Jeayoung Ryu, Kisang Son, 2011) it has analyzed the effect of train driver's "confirmation of points and answer" on railway accidents. More than 80% of the train drivers recognized that "confirmation of points and answer" affect the occurrence of railway accidents. and there are previous similar patents((1)Automatic train stop control system for stop position of train, Korea patent No:10-0756187B, 2007, (2)Train drivers guidance warning system using wireless communication data, Korea patent No:10-1089819B, 2011, (3)Terminal equipment computer assisted of train, Korea patent No:10-1049039B1, 2011) related with "confirmation of points and answer" system.

But comparing those previous patents with the present invention, there is no system configuration for inducing and forcing a train driver's "confirmation of points and answer"

## 5. CONCLUSION

Metro train driver's human factors(errors) account for a large proportion of railway and train accidents. And by inventing 'Intellectual confirmation of points and answer voice recognition system', it is effective in preventing human errors in train operation part. And it can also prevent of civilian safety accidents, such as entrapment of passengers at car doors/PSD(Platform Screen Door), reduce the amount of property damages caused by train driver's human errors, reduce the passengers inconvenience and make it strengthen the competitiveness of railway industry.

Seoul Metro executed pilot operation (21.12.2021~31.03.2022, running 6 trains) With the system, and there were "Zero" human errors happened during the period. And it has planned the system to be expanded through line No.1~8 and also added more functional features into the systems; train status information, train accidents information in certain platform, train operation schedule, etc. Through continuous practical improvement of dataization and statistical management during system operation period, it is expected that the system will affect train driver's "confirmation of points and answer" to be habituated.

**Keywords**: Railway safety; Train driver's human errors; Intellectual confirmation of points and answer voice recognition system; Prevent train accidents

**REFERENCE**

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4) Patents; (1)Automatic train stop control system for stop position of train, Korea patent No:KR200435599Y1,2007, (2)Train driver guidance warning system using wireless communication data, Korea patent No:KR10-2089819,2011, (3)Terminal equipment computer assisted of train, Korea patent No:10-1049039B1, 2011