A Conversation-based System for School Building Inspections

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Abstract –

This research aims to develop a conversation-based system for school building safety inspections. The safety of school buildings requires routine and additional post-disaster inspections. However, the inspections are often complicated due to various timings and sets of checkpoints for different situations. In addition, the traditional paperwork process is not convenient for assessors to add additional images for detailed descriptions. Moreover, managers may face the inefficiency of grasping situations from numerous paper reports. To solve these problems, we developed a chatbot to notify, guide, and assist assessors to complete safety inspections, and a dashboard for managers to consume reports in order to determine whether further assessments or retrofits are required. In this research, we digitalized the process of safety inspections and developed a chatbot to notify and guide the assessors to complete their tasks. When an earthquake occurs, the chatbot notifies the assessor if the intensity scale of the earthquake meets the school building's safety threshold. The chatbot then guides the assessor to complete the inspection. The assessor may interact with the chatbot for further instructions and upload pictures of damaging. The system collects the reports from all schools, analyzes the data, and displays via the dashboard we designed for the managers which enables the managers to efficiently and correctly consume the reports for making decisions. The conversation-based system provides an effective interface for reducing the inefficiency of school buildings' inspections, featuring automatic notifications for assessors, a conversation-based interface for guiding assessors to accomplish inspections, the integration of intuitively concatenating the whole process of inspections, the acceptability of multimedia for lowering possibility of inspection mistakes, and the view of data visualization for decision supporting of the manager.

Keywords –

Conversation-based system; Building safety inspection; Decision support; Chatbot; Data visualization

1 Introduction

The earthquake occurrence is quite frequent in Taiwan since Taiwan is located on the circum-Pacific seismic zone. The annual average number of earthquakes recorded from 1991 to 2004 increased to 18,649, of which approximately 1,047 were felt [1]. Despite the common occurrences of earthquakes, the majority barely causes bare damage to buildings and infrastructure. However, there were some destructive earthquakes, such as the magnitude-7.3 Chi-Chi Earthquake in 1999, which destroyed nearly half of the school buildings in Central Taiwan, and eventually damaged over 600 school buildings [2].

Due to the frequent occurrences of earthquakes in Taiwan, the Ministry of Education has ordered all public schools to establish "safety inspection task forces" for evaluating the seismic resistance of existing school buildings [3]. The safety inspection task force of each school is composed of the principal, the president of the parents' association, the director of general affairs, and other staffs of the school. Besides routine inspections once a year, additional inspections on irregular bases are required, especially after the occurrences of disasters including earthquakes that meet the critical safety thresholds. Based on the results of inspections, the managers who make decisions of budget allocation determine how to allocate resources for school building repairing.

The number and spatial complexity of school buildings make it tedious for assessors to repeat the inspections multiple times on different buildings. In addition, paperwork restricts forms of reporting inspections; multimedia such as images and videos are hardly accepted even though they provide richer information about building damages. Moreover, such numerous paper-form reports hinder managers to grasp the situation of potential damage. Currently, the evaluations are paperwork and cover at least 20 checkpoints. Also, the members of safety inspection task forces usually do not have expertise in structural or civil engineering. The process of inspections may be quite a burden to the assessors, and the results may not completely illustrate the building damages to the managers.

The evolution of information and communications technology (ICT) has enhanced developments in communications and electronic devices. Wireless protocols and techniques make it possible to connect to the Internet regardless of time and location. In addition, electronic devices are smaller and more powerful than in the past; nowadays, people can access, process, and produce information online via smartphones at anytime and anywhere. Electronic devices are adapted to constructions problems to eliminate the difficulty due to paperwork; for example, iSafe, an iPad application, improves day-to-day practices and management of safety inspections, and allows consistent data collection that can eventually be used to aid the development of advanced safety and health data analysis techniques [4]. However, despite the popularity of smart devices to access the web, traditional designs of user interfaces are not ideal for the reduced size of the screen and keyboards of smart devices [5]. Graphic user interfaces designed for tablets may not fit with smartphones, which are more popular than tablets [6].

On the other hand, the growing popularity of smartphones has triggered the growth of messaging applications. The number of people using messaging applications has surpassed the number of people using social networks since 2015 [7]. Such a phenomenon has promoted chatbots as a new trending solution for trivial problems in people's life and work. Recently, chatbots are widely used in several areas, including economic, medical, and disaster management [8].

For construction projects, most chatbots are aimed to assist the management of work sites. Some chatbots are adapted to assist scheduling future works and remind managers to fulfill scheduled daily tasks; for example, ConBot, a construction site data assistant produced by Botmore Technology in the UK [9], and SafeTrack, developed by Talania Ltd in New Zealand [10], allows workers and managers to submit daily reports and information of accomplished works via dialogue. In addition, there are other chatbots that focus on site safety issues, such as Workplace Safety Bot, a chatbot developed by the Robust Tech House of Singapore, which allows users to report hazards easily and broadcasts safety reminders to users [11].

Chatbots have lower resistance than smartphone applications for users because of the needless of additional downloads and installations. It is not necessary for users to download any additional application which may occupy storages of devices. Only adding chatbots to contact lists is required for acquiring services. For most messaging applications, adding chatbots to contact lists is equivalent to adding true people. Also, conversations can be opened simply to offer specific services. Since chatbots are based on dialogue interface, users don't need extra efforts to be familiar with how to use the services. By contrast, it takes more time for users to learn how to use smartphone applications.

According to an online survey report [12], chatbots outperformed applications in the following five benefits categories: quick answers to simple questions, getting 24-hour service, quick answers to complex questions, ability to easily register a complaint, and getting detailed/expert answers. The detailed survey results are listed in Table 1. The percentages represent the proportion of respondents who associate the category with communication with business.

Table 1. Comparison of the top five benefits of chatbots which are associated with communication with business

Category	Chatbot(%)	Application(%)
Quick answers to simple questions	69	51
Getting 24-hour service	62	54
Quick answers to complex questions	38	28
Ability to easily register a complain	33	24
Getting detailed / expert answers	28	27

In conclusion, the convenience to access and capability to interact with users have made chatbots a new and feasible solution to integrate smart devices to all fields. Such benefits of chatbots make it a feasible solution to the complication of inspections, the inconvenience of the paperwork process, and the inefficiency of management for Taiwan’s school building safety inspections.

2 Objectives

This research aims to reduce the complication of safety inspections, the inconvenience of the paperwork process, and the inefficiency of management. The safety inspections are often complicated due to various timings and sets of checkpoints for different situations. In addition, the traditional paperwork process is not convenient for assessors to add additional images for detailed descriptions. Moreover, managers may face the inefficiency of grasping situations from numerous paper reports.

In this research, we developed a system to solve the problems above. The system uses a chatbot as an interface to notify, guide, and assist assessors to accomplish safety inspections, and a dashboard as the other interface for managers to consume reports in order to determine whether further assessments or retrofits are required. The developed system includes the following features:

1. **Automatic notification** for notifying the assessor to accomplish inspections after earthquakes if the safety threshold of the school is reached.
2. **Conversation-based interface** for guiding the assessor to accomplish inspections in a non-professional-friendly way.
3. **Integrated tool** for concatenating receiving notifications and the inspections task in a single tool or application in order to improve the intuitiveness of the whole inspection process.
4. **Acceptability of multimedia** for allowing the assessor upload images or videos for showing damages directly in order to lower the possibility of mistakes in inspections.
5. **Data visualization** for decision supporting of the manager in order to enhance the quality and accuracy of budget allocation for building retrofit.

3 Methodology

In this research, we digitalized the process of safety inspections and developed a conversation-based system to notify and guide the assessors to accomplish their tasks. The system includes 3 modules: (1) the notification module, (2) the conversation module, and (3) the display module. The system architecture is illustrated in Figure 1. All 3 modules connect to the database, storing data including intensity scale thresholds of areas, assessors' contact information of schools, earthquake records, and inspection reports. The notification module and the conversation module interacts with assessors in the form of the chatbot we developed. The display module is accessed via web browsers by managers.

The notification module is activated by receiving earthquake information when an earthquake occurs. The intensity scale of each area is considered when selecting critical schools to announce safety inspections. The system looks up in the database to select the schools which locate at areas of which intensity scale thresholds are reached and sends notifications for safety inspections to the registered assessors of the schools via instant messaging applications in the form of the chatbot.

The conversation module interacts with the assessor via the instant messaging application in the form of the chatbot. The assessor starts a new inspection after receiving the notification from the chatbot. The chatbot guides the assessor to complete the pre-designed checkpoints in the inspection. The assessor may interact with the chatbot for further instructions and upload pictures of damaging. The chatbot collects the inspection, confirms the content with the assessor, and submits the inspection to the system. The system stores the inspection reports in the database.

The display module manages the dashboard for managers to check out the status of inspections via web browsers. The display module reads the inspection reports from all critical schools, analyzes the data, and displays via the dashboard we designed for the managers which enables the managers to efficiently and correctly consume the reports for making decisions.

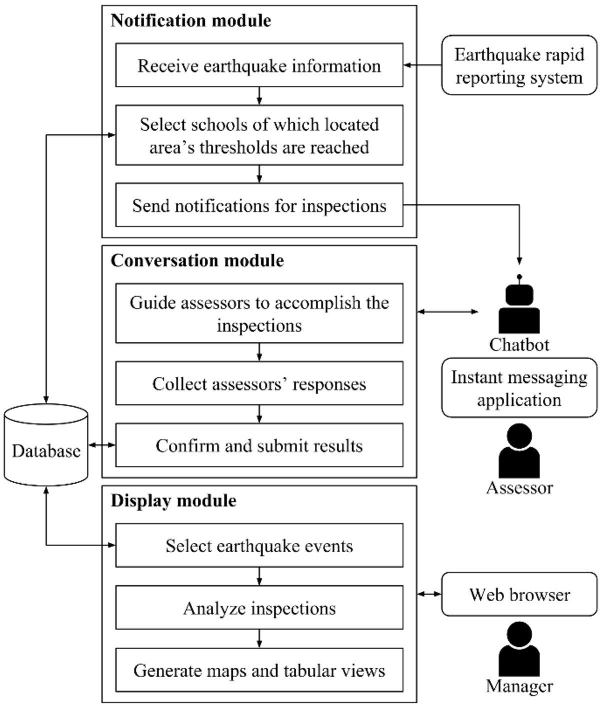

Figure 1. The system's architecture

3.1 Notification Module

The major task of the notification module is to inform the assessors whose schools locate in areas having higher intensity scales when an earthquake occurs. The procedure is illustrated in Figure 2. The notification module, connecting to the system's database, digitalizes the process of determining which schools require inspections and send notifications to the registered assessors of those schools, reducing the time of checking schools' thresholds and notifying assessors manually. The direct notifying messages sent to assessors' messaging applications are accomplished by the chatbot in their contact list as if they are sent by real people; the assessors may start the inspections smoothly by replying the chatbot when they receive the messages without switching to another application, improving the intuitiveness from receiving notifications to starting inspections.

When an earthquake occurs, the system receives the information including the center, the magnitude, and intensity scales of different areas. The notification module determines the areas which are critical by the intensity scale threshold of each area which is defined by experts considering the sensitivity of the area. The schools in the critical areas will be selected to announce safety inspections after the earthquake. Notifications are then sent by the chatbot via instant messaging applications. The assessors' messaging application accounts are bind with their schools when they add the chatbot to their contact lists initially. After the critical schools are selected, the notification module sends instant messages to announce the assessors of the critical schools for accomplishing safety inspections. For the schools that do not locate in critical areas, the notification module does not send messages to the schools' assessors since such schools do not require inspection.

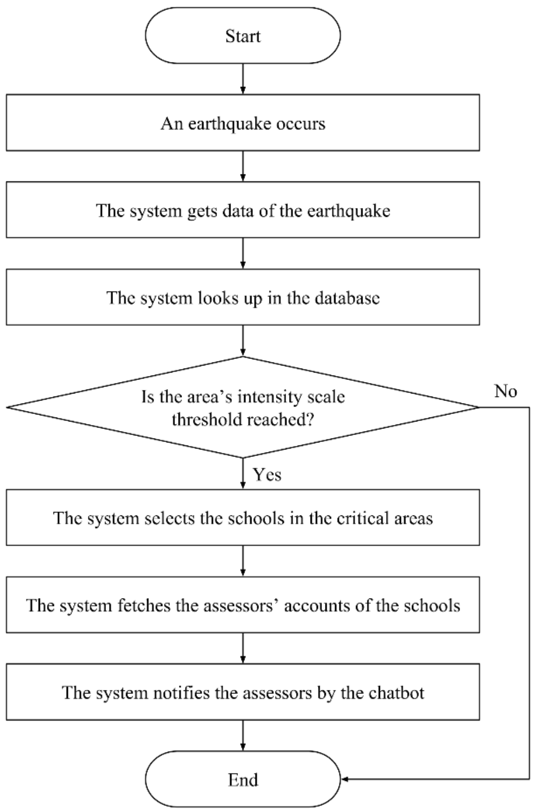

Figure 2. The process of the notification module

3.2 Conversation Module

The major task of the conversation module is to interact with assessors in the form of conversation in order to lower difficulties of assessors accomplishing the inspection. The procedure is shown in Figure 3. Since most assessors do not have expertise in structural or civil engineering, they may not be capable of accomplishing the complicated and tedious inspection checkpoints efficiently and correctly. The conversation module interacts with assessors with the chatbot, making inspections similar to having conversations with real people. The module guides assessors to accomplish the inspections, replacing the traditional paper-based procedure which lacks guidance for the non-professional assessors. The module also accepts multimedia file sent from assessors to the chatbot for clearer reports of damages, reducing the potential mistakes of inspection.

The assessors start the inspection by sending commands in text messages to the chatbot when receiving notifications. The chatbot asks assessors "questions" referring to the pre-designed inspection checkpoints. The inspection checkpoints are divided into 4 categories: overview, about indoor facilities, about outdoor facilities, and about facilities in corridors. The categories are set by roughly dividing building facilities. Assessors are allowed to start the inspection from anyone of the 4 categories. They answer the questions sequentially in the form of sending messages to the chatbot. They may pause in the inspection and continue accomplishing the remaining checkpoints later at any time they want since the conversation module manages the process of filling out the checkpoints; data of filled checkpoints will not be lost. In addition, assessors are allowed to send images and videos as if they are having conversations with real people via messaging applications. The chatbot collects the multimedia files as the answers to the checkpoints. The chatbot summarizes the contents into a message after accomplishing the inspection and presents it to the assessor for final confirmation. If modifying is required, the assessor may select the checkpoints to be modified and correct the answers. Finally, after the corrections are accomplished and confirmed, the system saves the results to the database.

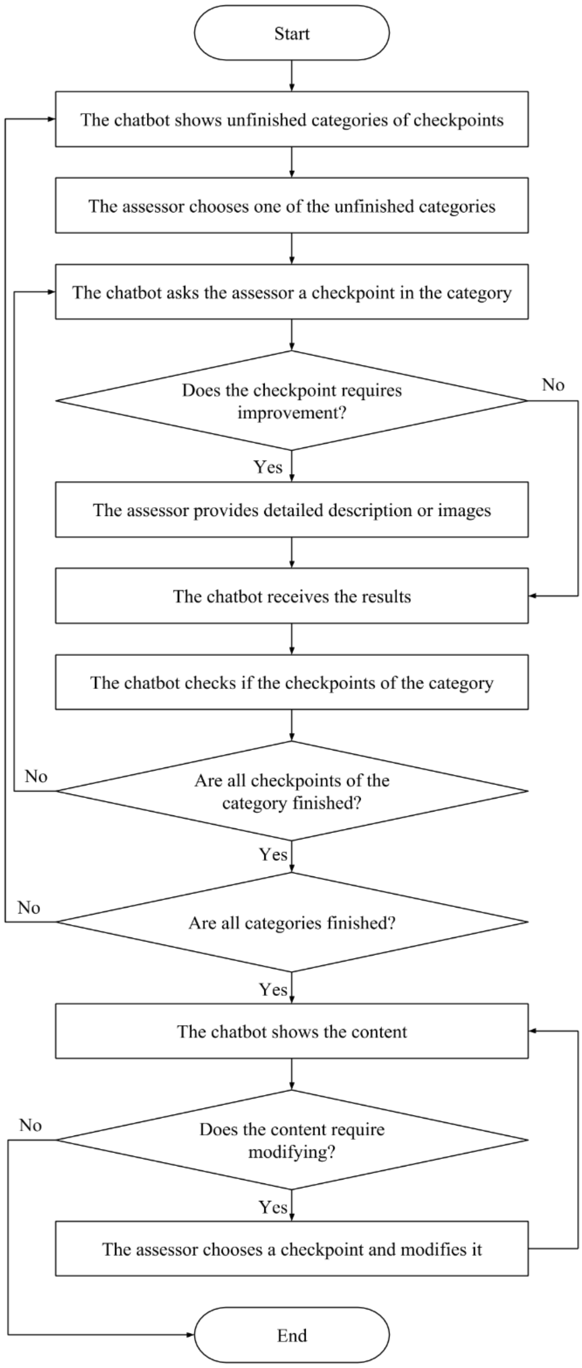

Figure 3. The process of the conversation module

3.3 Display Module

The major task of the display module is to demonstrate the results of the inspections by visualization in order to lower the inefficiency and difficulty for the managers to consume the data for making high-quality decisions. The procedure is illustrated in Figure 4. Managers need to grasp the situation of school building damages after an earthquake occurs and determine the budget allocation for building retrofit. The display module assists managers in selecting digitalize reports, analyzing the reports, and visualizing the results for decision support.

The dashboard is designed to access with web-browsers. The dashboard is composed of an interactive map showing the number of expected reports and a list of detailed inspection reports that are actually accomplished. First, managers select one of the earthquake events on the dashboard. Next, the system retrieves the reports of the selected earthquake event from the database and then shows them on the dashboard. The map demonstrates the number of critical schools in the areas by coloring them, while the tabular view lists all schools and their reports. By clicking one of the areas on the interactive map, reports of schools in that specific areas will be filtered and highlighted to emphasize the severe levels. Finally, managers consume and utilize the information shown on the dashboard to make decisions about allocating budgets and resources to retrofit the damaged school building.

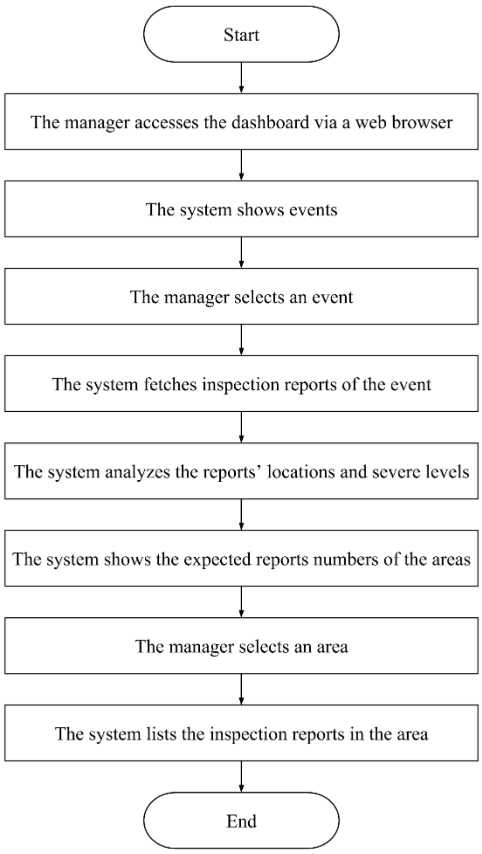

Figure 4. The process of the display module

4 Implementation

We implemented the conversation-based system as a chatbot via LINE, a commonly used messaging application in Taiwan. LINE Messaging API provides various types of messages include confirming button and accepts multimedia as users' responses [13]. These features are utilized in our developed system. Flask, a micro web framework written in Python [14], is used for implementing the system as an HTTP service to control the process of interaction with LINE Messaging API and host the web-based dashboard. The web-based dashboard is constructed using HTML/CSS/JavaScript in order to be accessed via any web browser.

Screenshots of part of the chatbot are shown in Figure 5. The chatbot interacts with assessors using diverse formats of messages provided by LINE Messaging API. The system informs assessors to start inspections after an earthquake occurs. The assessor selects one of the question categories and starts to fill in the report. Entire questions are displayed as confirming buttons. If the assessor selects "no problem", the next item for inspection will popup sequentially; if "require improvement" is chosen, the chatbot will be switched into input mode. The assessors are allowed to make detailed descriptions in text or with multimedia. After accomplishing the inspection, the system summarizes the current contents and presents it to the assessor for final confirmation. If modifying is required, the assessor may select the items to be modified and correct the answers. After the corrections are accomplished and confirmed, the system saves the results to the database.

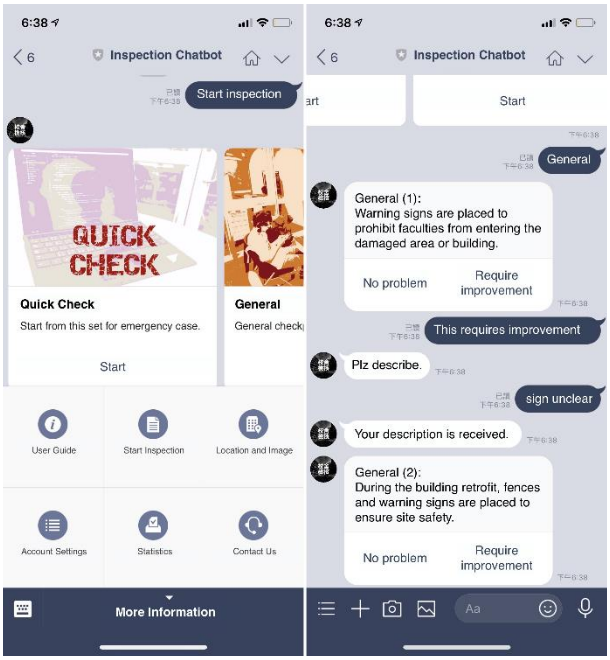

Figure 5. Screenshots of the chatbot

The dashboard for managers is shown in Figure 6. The dashboard is web-based and composed of an interactive map and a tabular list. The managers first select an earthquake event using the select bar, and then by clicking a district on the map, inspection reports of schools related to the earthquake event in the district will be listed with links to detailed results. The color demonstrates the severe level of each school according to the inspection records; the more checkpoints fail in the inspection, the darker the color of the report is. By clicking on one of the links to a specific detailed result, the result will be shown as in Figure 7. By default, only the items reported to be "require improvement" and their descriptions are displayed in the detailed result.

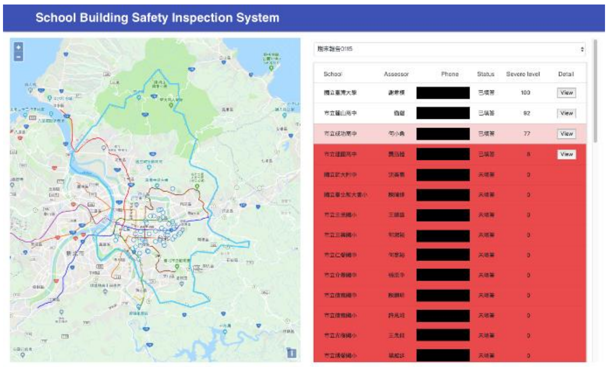

Figure 6. A screenshot of the dashboard

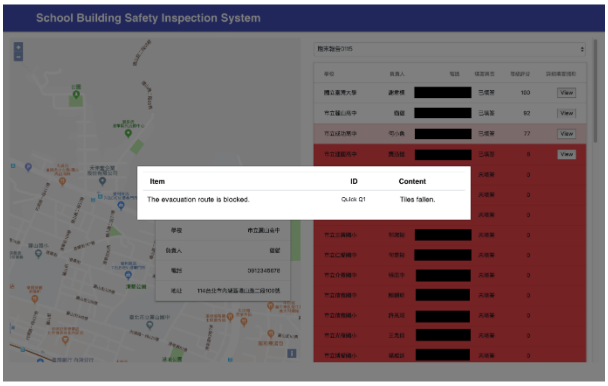

Figure 7. A screenshot of the dashboard after clicking on one of the inspection report for more details

5 Conclusions

In this research, we digitalized the process of safety inspections and developed a conversation-based system for notifying and guiding the assessors to accomplish their tasks. The system includes the notification module, the conversation module, and the display module. The notification module is activated by receiving earthquake information when an earthquake occurs and sends notifications for safety inspections to the registered assessors of the schools via instant messaging applications. The conversation module interacts with the assessor via the instant messaging application in the form of a chatbot which guides the assessor to complete the pre-designed checkpoints in the inspection. The display module reads the inspection reports from all critical schools, analyzes the data, and displays via the dashboard for the managers. The research provides a conversation-based solution to reduce the complication of safety inspections, the inconvenience of the paperwork process, and the inefficiency of management. The developed system features automatic notifications for notifying assessors, a conversation-based interface for guiding the non-professional assessors to accomplish inspections, the integration of intuitively concatenating receiving notifications and the inspections task, the acceptability of multimedia to show damages directly without possibility of mistakes, and the view of data visualization for decision supporting of the manager in order to enhance the quality and accuracy of budget allocation.

In future work, to improve our developed system and enhance managers' efficiency of grasping information, interviews with the managers for evaluating the design of the dashboard is required. Also, techniques of natural language processing may be adapted to analyze text in inspection reports in order to obtain more accurate severe levels of the inspection reports, which may support the managers determine the budget allocation. In addition, techniques of image recognition may be adopted to find damages from assessors' uploaded images automatically and reduce the time for managers to check the images manually. Furthermore, to obtain the accurate positions of building damages, a method to clearly describe the positions is required. Although by utilizing interactive image messages of LINE, assessors may report the positions of damages by clicking on an image of the site plan, the scale of images and the process of inspections require further discussions.

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