

Building Crack Inspection using Small UAV

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Abstract— As for large scaled skyscrapers, it is time-consuming, requires a significant amount of expenditures, and too risky for an inspector to examine in person with tools on hands. Therefore, unmanned aerial vehicle is specifically required to inspect the facilities in order to deal with limited access of an inspector, to examine multiple structures, and to confirm whether the inspected areas are damaged in each season or daily time frame. This study is intended to specifically develop the small aerial vehicle-based Image acquisition system for the inspection of structures aiming to identify the cracks of the building. Hereupon, safety inspection was conducted on the building. It is also intended to utilize the suggested system in this study to safety inspection in diverse fields of industry in the future.

Keywords— Small unmanned aerial vehicle, Image acquisition system, Monitoring facilities, Safety inspection, Image processing, Edge detection, Building crack.

I. INTRODUCTION

It is recently in an increasing trend that structures are damaged and collapsed. Especially, it is time-consuming, requires a significant amount of expenses, and too risky for an inspector to examine large-scaled skyscrapers in person with tools on hands. Therefore, it is difficult to provide an accurate diagnosis.

Therefore, it is urgently required to inspect structures by using unmanned aerial vehicle in order to deal with limited access of an inspector, to inspect multi-structures at a time, and to confirm whether the inspected areas are damaged in each season or daily time frame.

Unmanned aerial vehicle does not require a controller to board and hence is remotely controlled on the ground by a particular person. Therefore, it is called as 'drone' [1].

In the past, it was used for the surveillance on the target area or the military purpose. However, it recently started being utilized by the private sectors and also for research inspection including many other diverse purposes [2].

In this study, it is specifically suggested to use a small aerial vehicle-based Image acquisition system for inspection on structures. Suggested system uses Image acquisition algorithms designed to accurately detect whether a particular structure is damaged through videos or images recorded by using an aerial vehicle developing the program for users to conveniently operate. In addition, it is received with various sensor data making it feasible to conveniently identify the current status and designing the program that visualizes data.

This system is intended to install video camera on the small aerial vehicle approaching to the structure of skyscrapers through remote control, identifying the problem, and making it possible to precisely inspect and diagnose more accurately via image processing on the ground

II. RELATED WORKS

Definition and Applied Technology of Small Aerial Vehicle

Unmanned aerial vehicle (UAV) is a flight vehicle that man does not board on. Focusing on the fact that there is a person remotely controlling it on the ground, it is often called as uninhabited aerial (air) vehicle. It is normally categorized by the duty or flight altitude and scale [3].

As for the advantage of unmanned aerial vehicle, it is capable of performing the risky and difficult tasks that a human was in charge of in the past. Floating the vast area for a long time, it is able to supervise the risk of forest fire or to navigate the area that a human cannot enter due to contamination from radioactivity. Furthermore, it is also appropriate role of unmanned aerial vehicle to reconnoiter the area with high risk of being brought down by an antiaircraft missile [4].

Diverse scopes of study are being proceeded on the controlling technology of unmanned aerial vehicle to apply it on various fields including document recording or crop-dusting [5]. In addition, the image analyzing technology is currently being developed in the advance level that is capable of replacing physical sensors including the fire or movement supervision. [6].

It is in an increasing trend that maintenance and safety inspection of the structures are in a limelight mostly in Japan, Germany, and England. Hereupon, Fraunhofer ISE in Germany and Cyberhawk Company in England have developed and commercialized a small aerial vehicle for safety management of the wind power structures.

This study aims to install the camera on a small aerial vehicle recording the status of the structure in a remote control and inspecting the safety of structures through image process

Image Process Method and Algorithm

Image process indicates all ranges of the work producing and processing the image by using computer and also is related to all tasks related to the image including interpreting and recognizing the image.

Detection algorithm using the image process is being used in a wide range of industrial fields.

Image process was used to detect the cracks on the surface of concrete slab that specifically utilized the fuzzy inference mechanism and SOM algorithm [7]. In addition, image process was also utilized when developing the system that inspected on the bridge by using vision-based crack detecting algorithm [8].

This study is intended to use the changes in brightness converting the pre-recorded video to the gray scale and to develop the image acquisition system that detects damaged parts of skyscrapers by using the edge detection algorithm.

III. IMAGE ACQUISITION SYSTEM

A. System Overview

In this study, it is specifically suggested to program by utilizing a small aerial vehicle so that an operator is able to conveniently and accurately inspect damaged areas of structures through recorded videos or images in the use of image acquisition system. In addition, it is also suggested to develop a program that visualizes the data for easy identification of the status after receiving various types of sensor data.

The overall system flow is shown in the Figure 1.

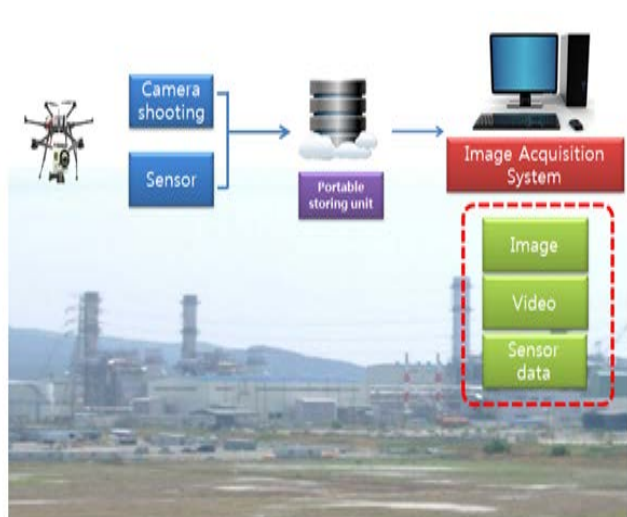


Figure 1. Outline of Image Acquisition System

B. Procedures of Acquiring Image

Image processing technology is required to acquire the image.

When the images delivered to the video camera or thermal infrared camera are damaged or ill-defined or when intending to look at the preferred areas in details, it is able to efficiently manage the data by using image processing technology.

In this study, it is intended to develop the API-based applied program for Window by using algorithm that detects the damaged areas of buildings through the procedures of acquiring image as shown in the Figure 2.

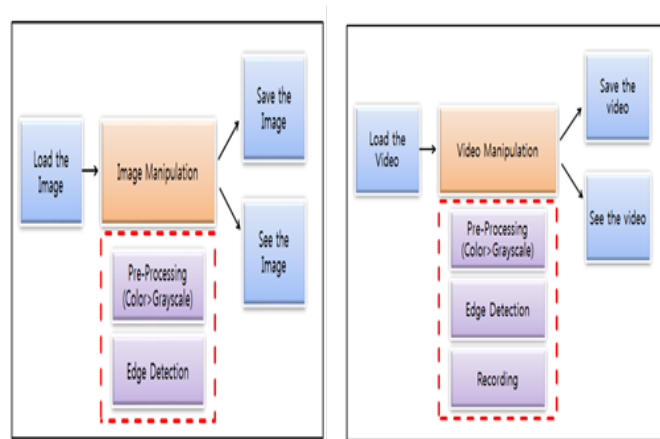


Figure 2. Procedures of Acquiring Videos

Suggested system separates the image processing procedures and video processing procedures.

C. Development Environment

Development environment of the program that was used to acquire the pre-entered video images is as follows in the Table 1.

TABLE 1. DEVELOPMENT ENVIRONMENT

Classification	Detailed Environment
CPU	Intel(R) Core(TM) i3 CPU M330 @213Ghz
RAM	2.0GB
OS	Windows7 Service pack 1
Language	C, Visual C++
Develop Tool	Microsoft visual studio2010
Library	Window API, Opencv2.3.1, Chartlibrary
Device	LG Notebook

D. Image Processing Techniques

This system uses the aerial vehicle converting the recorded color image into gray scale and inspecting the safety or whether a certain part of the structure is damaged. Therefore, it is important to detect the accurate edge.

Especially, it is required to detect edges when detecting the cracked areas inside of the building. Most of the edges detection masks are sensitive with noises. Therefore, most of the cases tend to regard a low level of noise as edge and detect it. There is an edge detecting technique that uses canny mask supplementing such a weakness. However, it aims to detect strong edges that are not sensitive with noises.

Therefore, this system aims to identify damaged areas inside of the building by using Canny edge detection algorithm

IV. EXPERIMENT AND REALIZATION

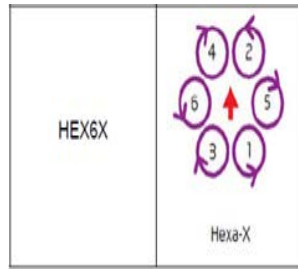
A. Experiment Environment

Hexa-copter, a type of small aerial vehicle, was used to identify whether a part of skyscraper was damaged to experiment and realize the plans in this study.

Hexa-copter board being used in the experiment was Black 32 consisting of gyro, acceleration pressure, and terrestrial magnetism sensor to provide a stable status of flight based on MultiWii open source.



(a)Hexa-copter used in the experiment



(b)Setup of flight mod

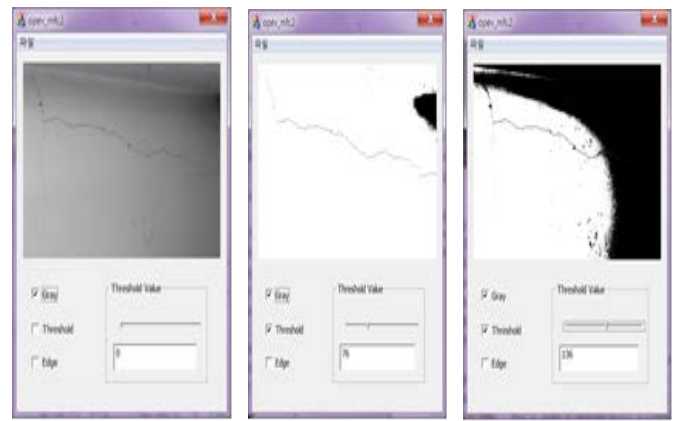
B. Result of Realization



Figure 3. Recorded images and also hexa-copter used in the experiment

Realized image acquisition system is comprised of two major programs. First one is to load the color image converting it to gray scale and also to edge detection to identify whether the structures are cracked either inside or outside.

According to the detection of crack image inside and outside of the building, it was relatively convenient to detect it. However, there were several cases that a tiny part of crack was not well detected.



(a)Grayscale

(b)Threshold= 76

(c)Threshold= 136

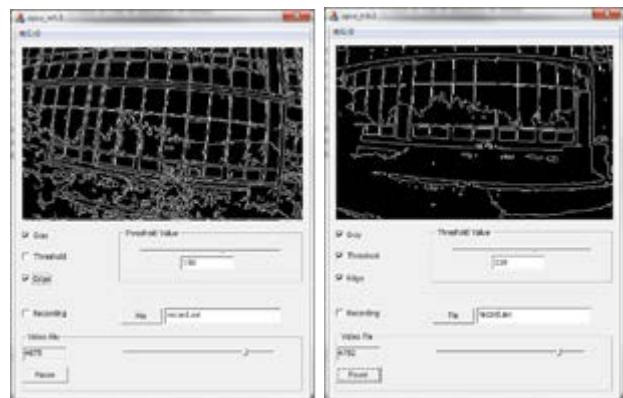
Figure 4. Experiment of Detecting the Crack of Buildings

The second image represents the program that loads the video image making it possible to see the image by processing immediately. Furthermore, it is available to capture and save the screen and also to receive the input from a camera if needed.



(a)Video Image

(b) Gray Scale



(c)Edge Detection

(d)Apply Threshold Values

V. CONCLUSION AND FOLLOW-UP STUDY IN THE FUTURE

In this study, a design of the small aerial vehicle-based image acquisition system for inspection of structures was suggested. Furthermore, the image acquisition system was realized as well.

Image processing algorithms were used to process the video image that was acquired by aerial vehicle removing the noises and leading to determine whether the structures were damaged through detection of edge.

It is currently planned to proceed follow-up study intending to acquire very safe and objective test procedures and also results compared to the previous method by providing more of convenient work environment by installing various types of sensors, thermal infrared camera, and various types of sensors on the small aerial vehicle by visualizing the data in the future.

Therefore, it is ultimately intended to apply it on the safety inspection of transmission towers, plant smokestacks, bridges, and piers that are dangerous and difficult for a person to approach based on aforementioned design.

It is much anticipated for the suggested system in this study to be highly useful on the safety inspection in diverse fields of industry in the future.

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