Automating Visual Data Processing to Support Post-Earthquake Reconnaissance

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Motivation: NHERI Five-Year Science Plan

NHERI is the next generation of National Science Foundation (NSF) support for a natural hazards engineering research large facility.

KEY RESEARCH QUESTION # 5 in this plan

How can the scientific community collect and share data and information to enable transformative research and outcomes?

Develop regional systems to collect and analyze sensor and image information for use in planning, mitigation, response, and recovery.
Key Idea: Automated Processing of Big Visual Data

A large collection of images after disaster

Various image collection platform

Robotic platform
Satellite imagery
Smartphone
Social media
Flickr
Google
Wearable dev.
Crowd sourcing

Current visual data classification

Various types, size, contents

Processing

Autonomous image recognition

Computer vision

New visual data classification

Collapse
Spalling
Post-Disaster Reconnaissance Mission

Reconnaissance mission (Taiwan, 2016)

Building and building components

Metadata (recording information using images)
Automated Post-Event Reconnaissance Image Documentation

Collection of many images from a building after disaster

Automated analysis of images

Metadata e.g. date, time, location

Visual contents e.g. outside, building

Classifying and organizing information as a report

Linking all images into the report in various formats

How to support field engineers to readily find and analyze images
Deep Convolutional Neural Network (CNN)

Convolutional neural network

Object detection
Image classification
Drone navigation
Object segmentation
Construction of Big Disaster Image Database

- # of curated images: 85,000
- # of un-curated images: 490,000
- Total hours of reconnaissance videos: 10.5 hours
- # of events: 59 (EQ: 46, HR: 4, TN: 9)
- Image sources: datacenterhub, EERI, FEMA, CEISMIC, etc
- Current labeled classes: spalling, collapse, drawing, overview, etc

Taiwan earthquake in 2016 (14,102 images)
Nepal earthquake in 2015 (16,201 images)
Hurricane Katrina in 2011 (445 images)
Ecuador earthquake in 2016 (7,327 images)
L’Aquila (Italy) earthquake in 2009 (414 images)
Florida hurricanes in 2004 (1,178 images)
Designing Image Categories

Building overview

Measurement

Building exterior

Building interior

Drawing

GPS navigator
Sample Report Generation (Ecuador, 2016)

A sequence of the images collected from a single building

![Sequence of images](image)

Building information

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th># of images</th>
<th>Structural damage</th>
<th>Masonry wall damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecuador earthquake</td>
<td>July 16, 2016</td>
<td>93</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
</tbody>
</table>
Automated Reconnaissance Image Organizer (ARIO)
Create a reconnaissance report
Review the report
Export the report
Potential Function 1: Earthquake Damage Recognition
Collapse Classification and Spalling Detection

**Collapse**
- Image showing that the buildings or building components:
  - lost their original shapes
  - produce a large amount of debris

**Spalling**
- Image including:
  - exposed masonry areas in a wall due to cracking
  - exposed rebar in a columns
  - small section loss due to large cracking
Potential Function 1: Earthquake Damage Recognition
Sample of Collapse Classification
Potential Function 1: Earthquake Damage Recognition
Sample of Spalling Detection
Potential Function 2: Automated Recovery of Structural Drawing
Collecting Partial Drawing Images during Field Missions

Images collected from a single building after the 2016 Taiwan earthquake

Sample partial drawing images captured from a drawing
Potential Function 2: Automated Recovery of Structural Drawing Demonstration of the Developed Technique

- Structural drawing printed on a large engineering paper
- Partial drawing image captured from the original drawing
- High resolution full drawing image
Conclusions

We developed a novel approach for **rapidly and autonomously classifying and organizing** post-event reconnaissance building images.

As the use of drones and other data collection system increases, and more images are collected in future missions, **automation will be essential** to organize and understand the data.

We envision that our tool will support real-world natural hazard reconnaissance missions leading to **safer infrastructure and more resilient communities**.

- Collect more valuable data in the field
- Understand gaps in structural design codes
- Mitigate potential loss in future events
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• EUCentre (Pavia, Italy)
• The Instituto de Ingenieria of UNAM (Mexico)
• FEMA and EERI
Use and Citations

To use the ARIO tool, please email me at: sdyke@purdue.edu

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Questions