Automated Detection of Pre-Disaster Building Images from Google Street View

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Post-disaster Reconnaissance

Hurricane,
Tornado, Flood

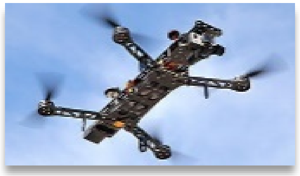
Major hurriane events in USA

- Harvey, Irma, Maria in 2017
- Patricia in 2015
- Sandy, Issac in 2012
- Rita, Katrina in 2005

Post-disaster reconnaissance

- Conducting rapid structural evaluation
- Collecting data (e.g. images, measurement)
- Evaluating flood damage
- Reporting repair costs

Collection of Post-disaster Reconnaissance Images



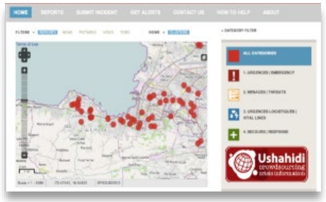
Robotic platform

Satellite imagery

Social media

Wearable dev.

Smartphone

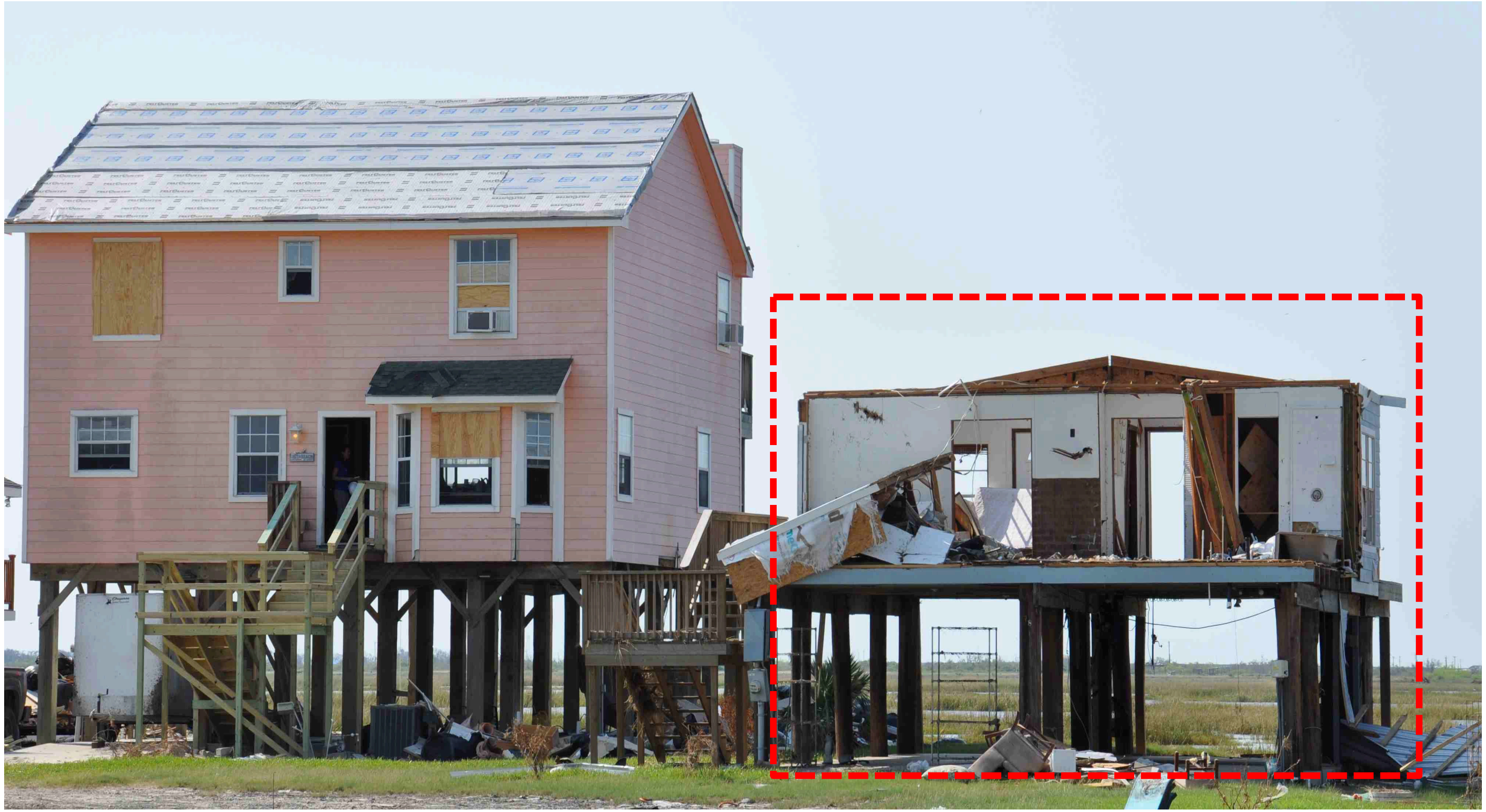


Crowd sourcing

Various image collection platforms

Collecting images from damaged buildings

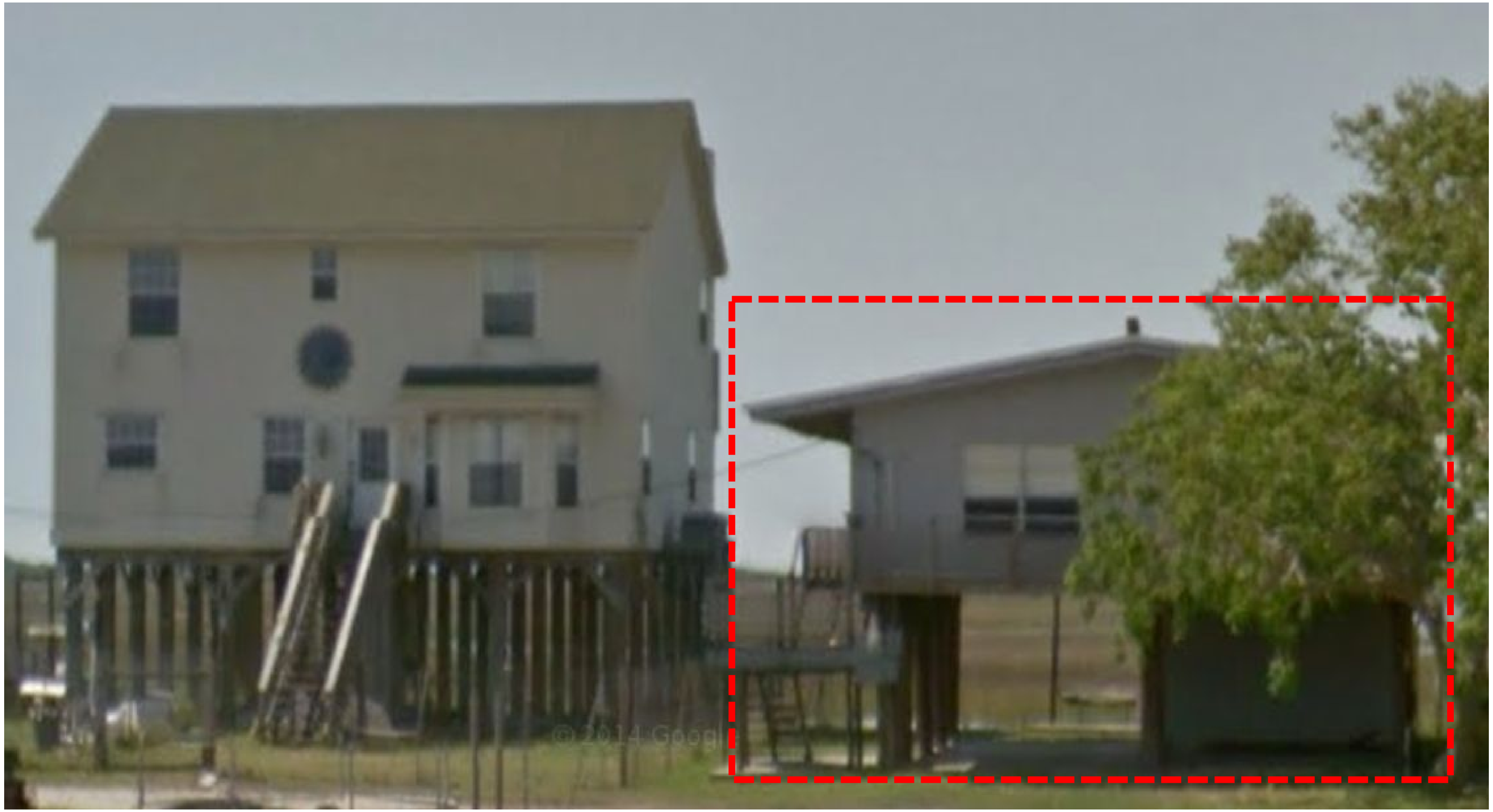
Motivation: How to Make Those Images More Useful?



After Harvey hurricane in Rockport, TX (Courtesy of Tom Smith)

Is this sufficiently informative?

Motivation: Integration of Pre-disaster Images using Google Street View



Before Harvey hurricane in Rockport, TX (Google Street View)

Images from various viewpoints

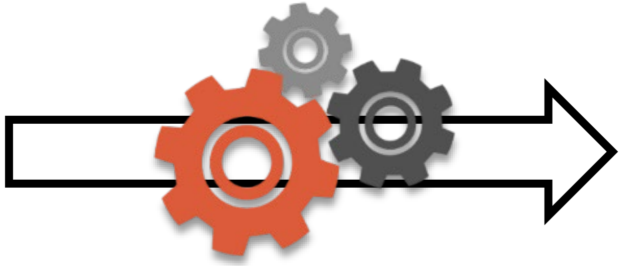
Objectives and Advantages

Objectives

Automatically extracting and detect pre-disaster building images from Google Street View images using computer vision techniques

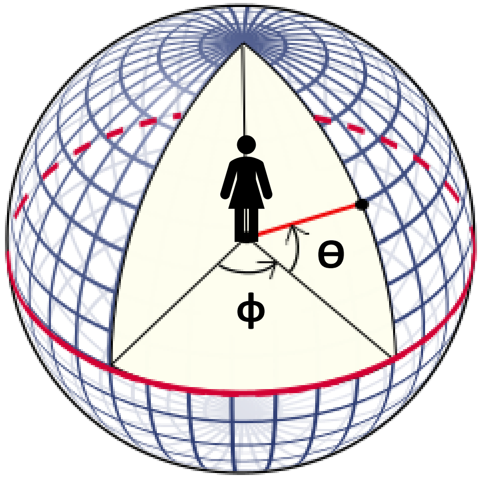
Advantages

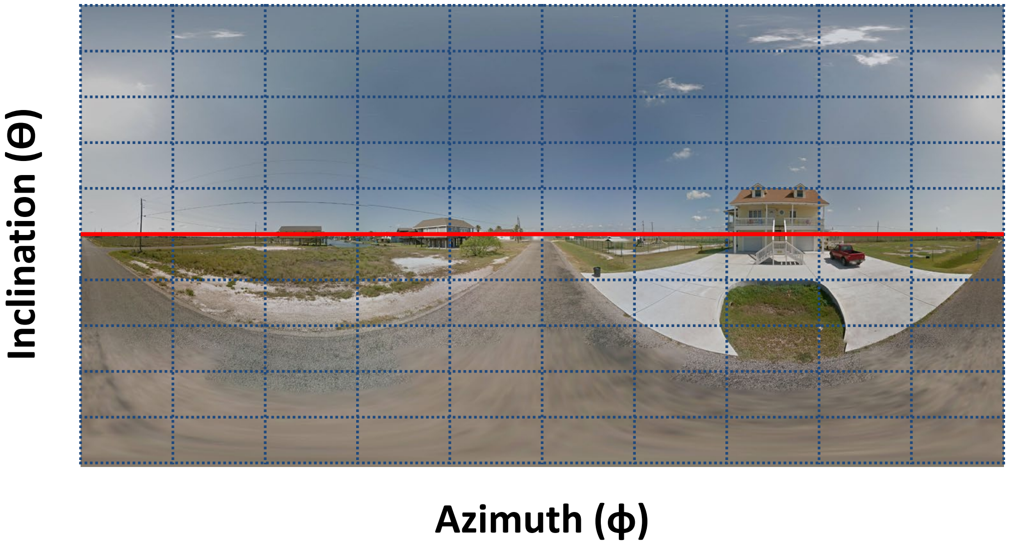
- **Fully-automated and rapid extraction of pre-disaster building images**
- **Exploiting high-resolution building images under various viewpoints/from various years**



360° Panorama and Rectilinear Image

360 panorama
(stored in Google Street View)





Rectilinear image
(what we have seen from its viewer)

Problem Statement

Time-consuming manual process

Rectilinear with an incorrect direction

Rectilinear with a proper direction

Problem Statement (Continue)

- Time consuming process to observe pre-disaster building images

  → Implementation of automated building detection

- Unwanted large distortion of a building on rectilinear images

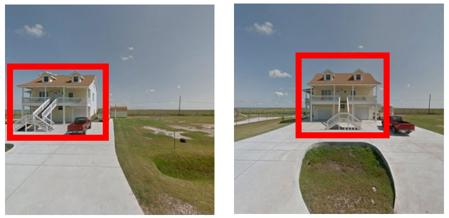
  → Optimal viewing angle estimation using multi-view geometry

Overview of the Technical Steps

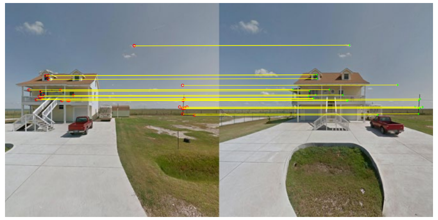
(a) Read input GPS from a geo-tagged image

(b) Download 360° panoramas (PN) near input GPS

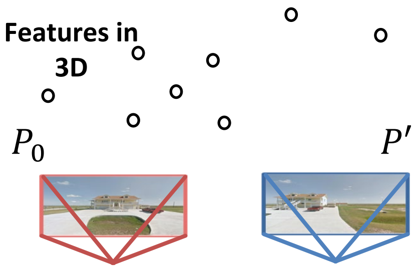
(c) Generate two rectilinear images (RT) from the nearest PNs to the input GPS



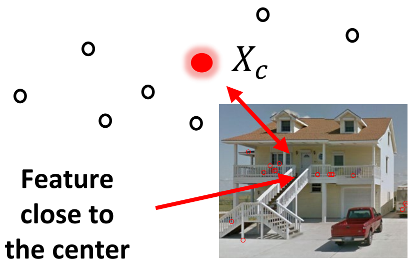
(d) Detect a building from each of these RTs



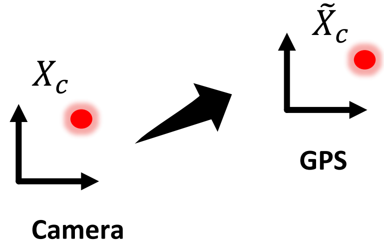
(e) Extract and match features



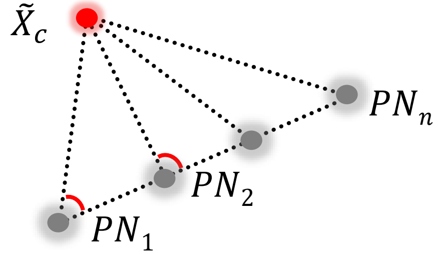
(f) Estimate projection matrices



(g) Define a approximate location of the building



(h) Transform the coordinate system



(i) Compute a direction for each PN

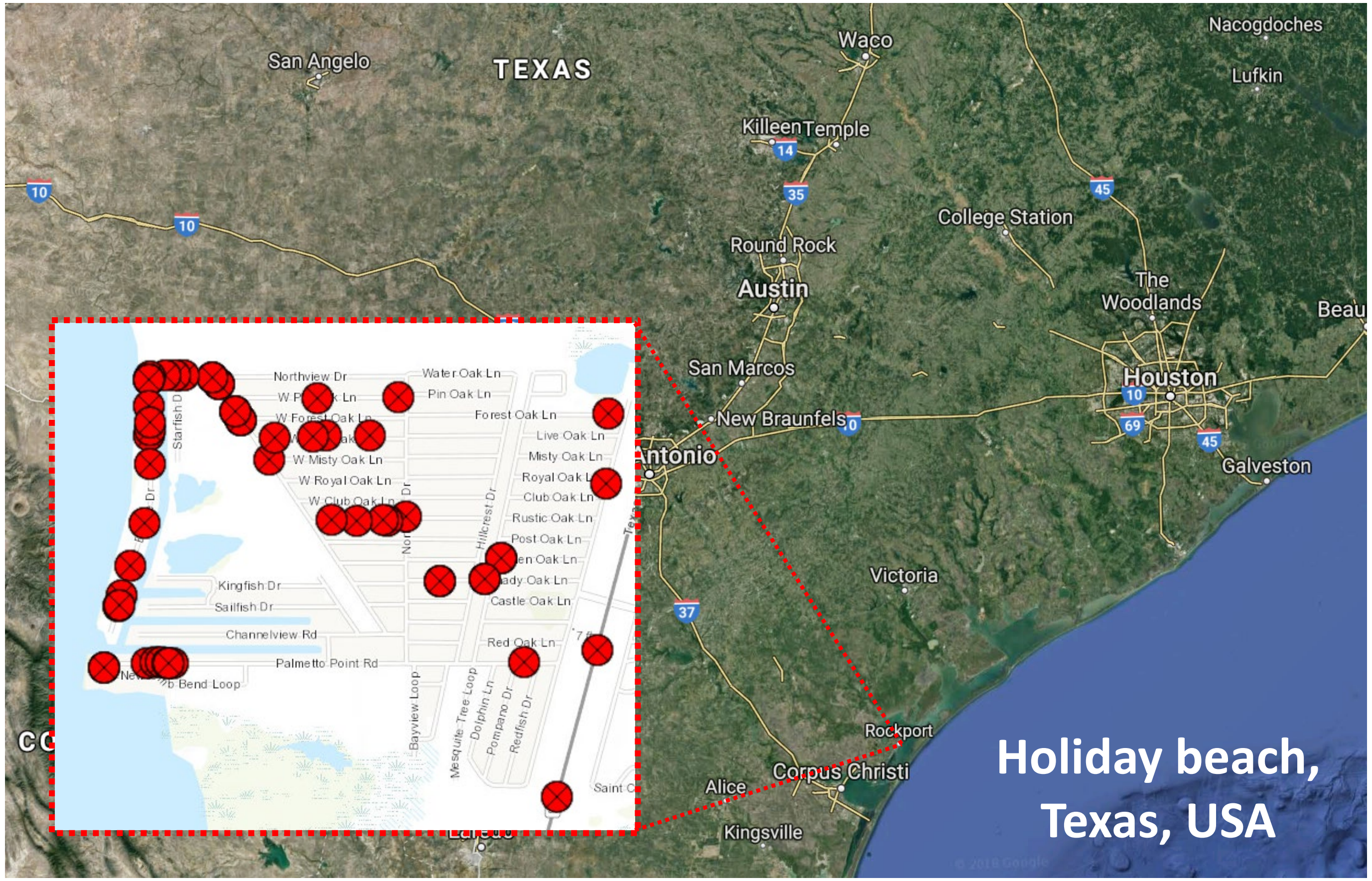
(j) Extract the optimal RTs by considering their direction

(k) Detect a building from the optimal RTs

(l) Localize building images

- Stage 1: Download the panoramas (PN) near a target building
- Stage 2: Compute the building location in GPS
- Stage 3: Generate the optimal rectilinear images (RT) using their proper direction
- Stage 4: Detect the target building from each of rectilinear images

Experimental Study: Input Geo-tagged Reconnaissance Images



Locations of inspected houses

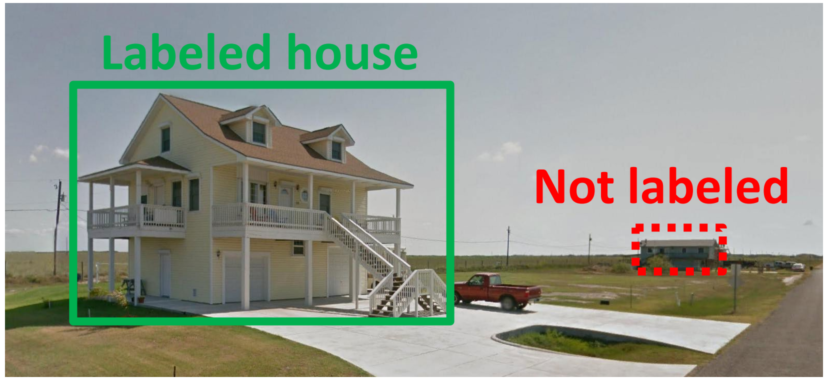
Post-disaster reconnaissance images

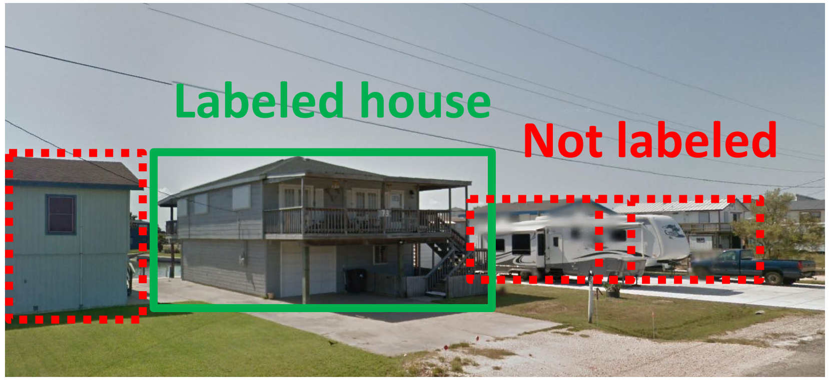
Training a House Image Detector using RCNN

- Architecture: Faster R-CNN and ResNet
- # of houses: 100 (at holiday beach)
- # of bounding boxes: 3500
- # of images: 1100
- Learning rate: 0.001
- Momentum: 0.9
- Weight decay: 0.0005
- Confidence threshold: 0.5
- NMS threshold: 0.3
- Training/testing: 60/40 %

Configuration for training

Testing result: 85.4% (average precision)





Labeling house images for training a classifier

Samples of house detection testing results

Sample Result: Providing an Input Geo-tagged Image

Input: Geo-tagged post-disaster images collected during residential building reconnaissance missions

Sample Result: Downloading the Panoramas Near a Target Building (Stage 1)

Input: Geo-tagged post-disaster images collected during residential building reconnaissance missions

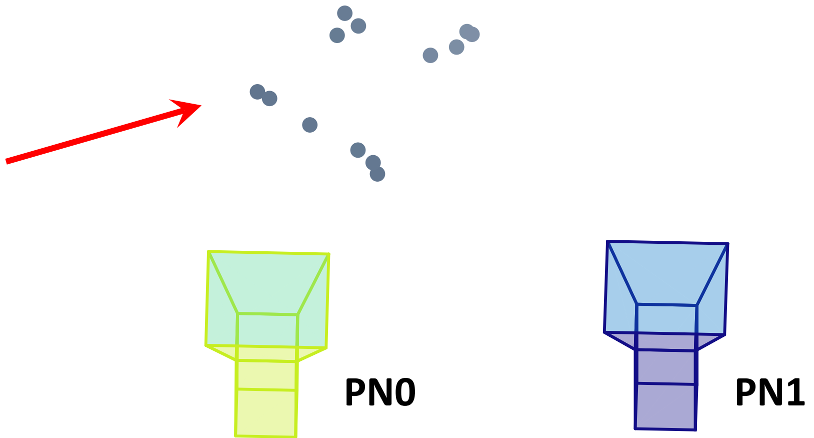
Raw 360^{o} panorama images downloaded from Google Street View

Sample Result: Computation of the Building Location (Stage 2)

Input: Geo-tagged post-disaster images collected during residential building reconnaissance missions

Feature extraction and match

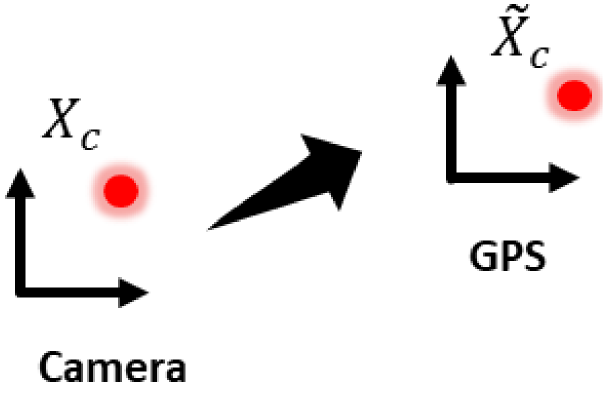
One of the points is selected as the house location (close to the center of the house)



3D point cloud created from camera geometry

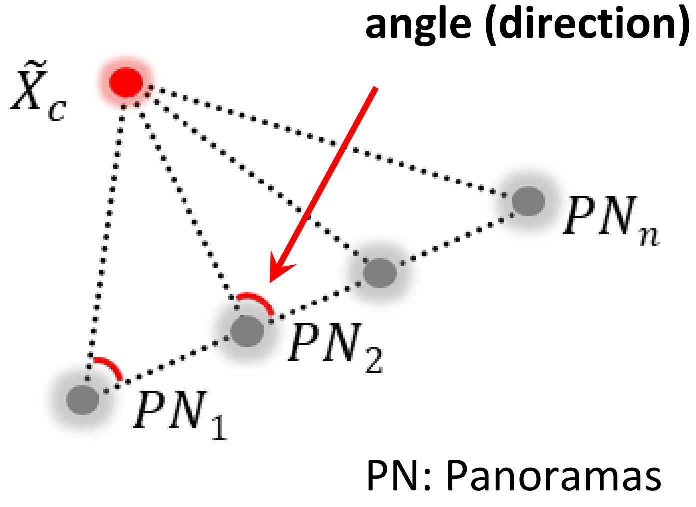
Sample Result: Generation of Optimal Rectilinear Images (Stage 3)

<u>Input:</u> Geo-tagged post-disaster images collected during residential building reconnaissance missions



Known
- **Cam. locations in the camera coordinate**
- **House location in the camera coordinate (X_c)**
- **GPS locations of the panoramas (cameras)**

Unknown
- **GPS location of the house ($\tilde{X}_c$)**



Computation of the angle

Sample Result: Generation of Optimal Rectilinear Images (Stage 3)- Continue

Input: Geo-tagged post-disaster images collected during residential building reconnaissance missions

Optimal rectilinear images are generated from each of the panoramas by considering its direction to the house

Sample Result: Detection of the Target Building from RT Images (Stage 4)

Input: Geo-tagged post-disaster images collected during residential building reconnaissance missions

House images can be detected and localized by applying the trained house image detector to the rectilinear images

More Sample Pre-disaster House Images

Post-disaster images

Pre-disaster images extracted from Google Street View

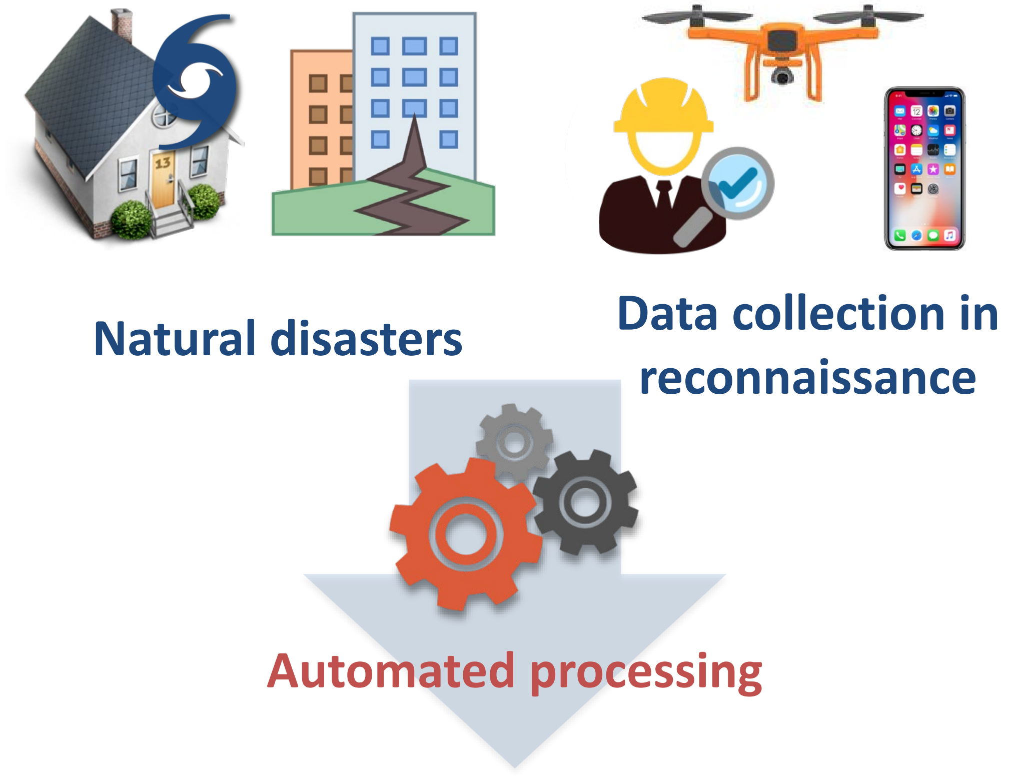
Needs for Extracting Building Images from Various Viewpoints

Post-hurricane image

View of the house obstructed by foreground object(s)

Conclusion and Long-term Vision

- We developed an approach for rapidly and autonomously extracting the pre-event building images from Google Street View.
- We incorporated state-of-art computer vision algorithms to automatically process Google Street View images.
- We successfully demonstrated the capability of our technique using actual post-hurricane reconnaissance images.
- This study provides a great example of how to exploit a large volume of legacy visual database for interdisciplinary research.



- **Collect more valuable data in the field**
- **Understand gaps in structural design codes**
- **Mitigate potential loss in future events**

Question ?

Acknowledgements

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