Earthquake Reconnaissance

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Introduction

Earthquake reconnaissance, or the collecting of data from earthquake damaged buildings and infrastructure, and earthquake damage documentation is one key area of research at The Pacific Earthquake Engineering Research Center (PEER). With real-life examples of earthquake impacts, researchers are able to collect data on how forces from earthquakes can affect man-made structures. The data that they collect ultimately helps them improve existing structures. A team of researchers, including Mr. Eduardo Fierro, BFP Engineers, Inc., Berkeley, CA, Dr. Eduardo Miranda, Stanford University, Dr. Khalid Mosalam (PI: Principal Investigator), University of California, Berkeley, and Dr. Shakhzod Takhirov documented recent damage by the 2010 Haiti Earthquake. Instruments such as the Leica Geosystems High Definition Survey Laser Scanner (HDS Laser Scanner) (figure 4) and Panoramic High Definition Camera (Panoramic HD Camera) (figure 5) were used in the Haitian field study to document structures, earthquake damage, and collect data to be used to help improve existing reconnaissance technology, as well as assess damage to buildings in Haiti .

Figure 1: Laser Scan of the Asscotia Hotel and intersection. Colored by the intensity of the light received by the Scanner.

Background & Motivation

The recent Haitian earthquake in January 2010 was a magnitude 7.0, killed 223,000, injured 300,000 and cost upwards of 13.2 billion dollars (USGS). In addition, death from earthquakes seems to be a function largely of construction methods and quality with a smaller emphasis on magnitude.

Figure 2: HD image of a damaged bridge in Port Au Prince, Haiti.

Previous work in reconnaissance consisted of still photography and observations done by the researchers participating in the study. They reflect observations and thoughts presented by the researcher with little objective data for others who are unable to recreate the trip. Figures 1 and 2 represent still photography taken on such a reconnaissance trip.

Figure 3: Global view of the bridge in figure 2. Colored by colors from the on board camera.

Materials and Methods

Photos, scans, and other data were taken from various sites in Port Au Prince, Haiti from buildings and structures damaged but not fully collapsed by the Earthquake.

Leics Geosystems HDS Laser Scanner: The Scan Station 2 (figure 4)manufactured by Leica Geosystems scans a building recording data points into a 3D space called a Scan World, which can be viewed in the program Cyclone. I learned the basic techniques in scanning buildings and other specimens, practicing moving the scanner and laptop that runs the scanner's operations.

Figure 4: Leica Scan Station 2.

Leica Cyclone 7.0: Cyclone is a point cloud manipulation program used to visualize and manipulate data recorded by the HDS Laser Scanner. Each scan takes data points saved in a point cloud of the surface of the desired specimen. I used the program to stitch scans from different angles of a specimen together, reduce data to be analyzed in the program MatLab, apply texture maps created from the high definition panoramas, analyze and measure displacements and generate TruViews or a 3D view of the specimen allowing for a moderate amount of manipulation outside of Cyclone.

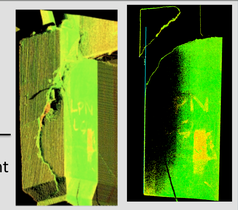
Panoramic Imaging: The Canon EOS 5D Mark II Camera (figure 5) paired with a Manfrotto Bracket and fisheye lens allowed researchers to take multiple photographs in one location that were stitched together using the program PTGui in order to create a panoramic photograph, an interactive .mov file, and a cube map that was used to create a texture map in cyclone in order to apply colors to a point cloud of a desired specimen.

Figure 5: Panoramic HD Camera.

Results

The use of new technologies and techniques has provided the group with the following results. Laser scans of the each specimen have proven useful in not only providing 3D imaging but also a tool in which analysis can take place. Cyclone's measure feature along with its ability to take horizontal and vertical slices allow for researchers to measure residual displacement within the program (figure 6), or export it for analysis in MatLab (figure 7). In addition, our findings have shown that different color schemes can be added to each of the projects. Figures 1, 8 and 9 show the three we experimented with. Figure 1 shows the intensity of light received, figure 9 shows colors applied from the camera on board the laser scanner, and figure 8 shows a texture map added from pictures taken using the photographs taken using the Manfrotto Bracket and Panoramic HD Camera at the same location. Google Earth was another aspect that was researched during the project. TruViews, or 3D interactive images that allow for rotation and measurements, as well as panoramic

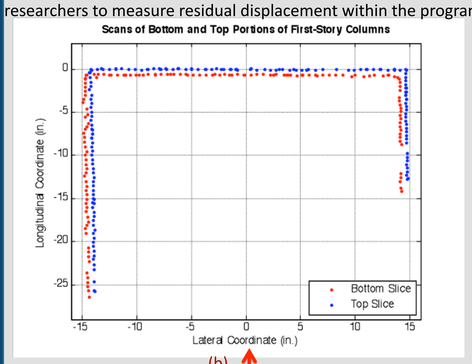
Figure 6: (a) Close up of Shear key of the bridge from figure 2. (b) Vertical slice of Shear Key face showing 0.067 meters of residual displacement.



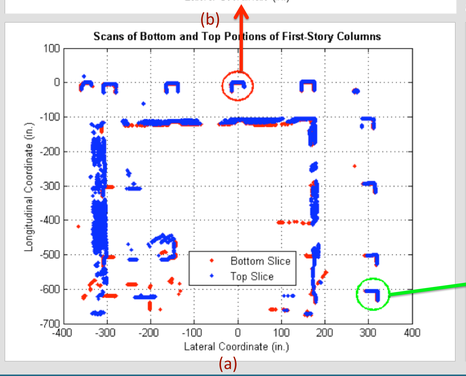
(a)

(b)

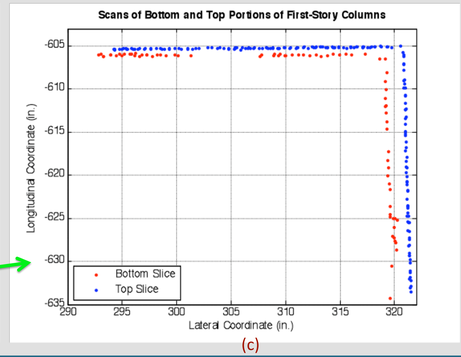
Images can be added to KML code used by Google Earth so that people all over the world can view the research team's panoramas, images, and collect their own data using the TruView's that the team created.



(b)



(a)



(c)

Figure 7: (a) Graph of residual displacement between 2.5 meters (red) up from scanner and 5 meters (blue) up from scanner. (b) and (c) Zoomed in column showing about 0.5 inches of residual displacement.

Conclusions

Earthquake reconnaissance is critical in the improvement of structures and buildings. It aims to improve our preparedness during major earthquakes. These technologies and techniques provide improved reconnaissance, data collection, and overall preparedness. The research team's Haiti reconnaissance has provided data that shows structure weak points and evidence for dynamics of movement during an earthquake. In addition, data taken from the Haiti reconnaissance can be analyzed and manipulated remotely through the use of Cyclone, Google Earth, and TruViews generated from Cyclone.

HD Photographic imaging and Laser Scanning both provide different forms of earthquake reconnaissance data. With photographic imaging, panoramic, interactive (in the form of movie files) and still photographs provide important visual aids of damaged specimens that can be viewed by people throughout the world. Laser imaging provides interactive 3D images that can be manipulated in various ways to provide other important data for researchers. The precision of the scanner allows for very fine scans that can be viewed and manipulated by people all over the world. They each provide different aspects to a field that will continue to change and provide researchers with important information about current and future building codes. Cost is the main disadvantage of both methods which prevents many from acquiring this technology and therefore acquiring the initial data. Our findings help in solving this disadvantage allowing others to gain access to TruViews and photographs through the use of Google Earth.

Figure 8: Laser Scan of the Asscotia Hotel and intersection. Colored by the texture map created in Cyclone using images from Panoramic HD Camera.

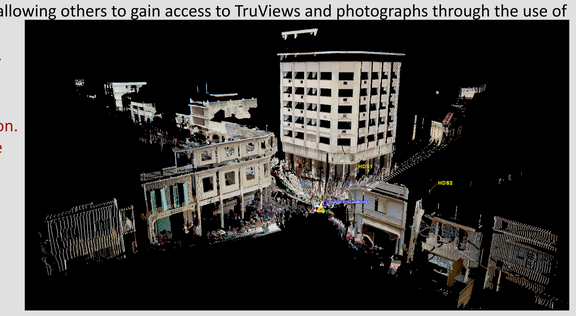


Figure 9: Laser Scan of the Asscotia Hotel and intersection. Colored by the colors from the on board camera.

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