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Remote assessment of pre- and post-disaster critical physical infrastructures using mobile workstation chariot and D^{4}AR models

M Golparvar-Fard & J Thomas
University of Illinois, Urbana-Champaign, IL, USA

F Peña-Mora
Columbia University, New York, NY, USA

S Savarese
University of Michigan, Ann Arbor, MI, USA

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This paper presents a novel systematic approach for disaster response and recovery of Critical Physical Infrastructures (CPIs). Our suggested approach is based on: (1) Using a Mobile Workstation Chariot (MWC) assembled on Segway personal transporter which supports both horizontal and vertical real-time visual data capture and transmission flow, first responders and civil engineers can quickly traverse hazardous terrain, collect and transmit photographs/videos, communicating with the command center in real-time. In addition, the MWC can become a mobile workstation/communication center in the field, supporting a group of first responders and civil engineers. (2) Using MWC wireless communication tools, first responders and civil engineers can access disaster-survivable black boxes allowing Building Information Models (BIM), pre-disaster photographs and operational information of buildings to be collected and communicated back to the command center. Fig.1 shows an overview of the proposed approach, data flow as well as its technological components.

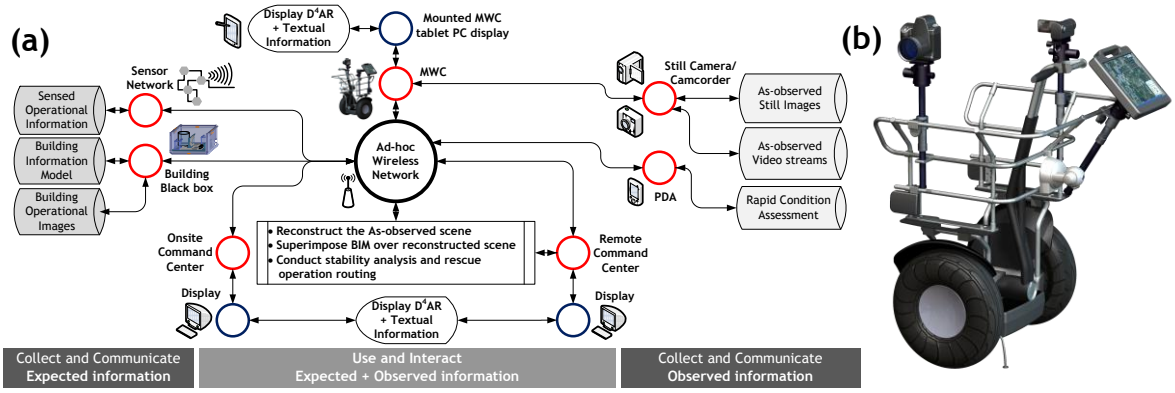

Figure 1, (a) An overview of the proposed approach, data flow and data collection, analysis and communication technological components. (b) MWC provides the ability to carry and use data collection and communication equipment during rapid response to XEs.

(3) Finally at the command center, using sensed visual data and Structure-from-Motion reconstruction technique, the post-disaster site is sparsely reconstructed and cameras are calibrated. The resulting integrated representation of the post-disaster model and the collected photographs are superimposed over the pre-disaster model to generate a 4D Augmented Reality (D4AR) model. The reconstruction in the integrated model is then improved by a multi-view stereo algorithm. Finally the scene is traversed voxel-by-voxel and each voxel is labeled and colored for occupancy and visibility (both from expected and observed points-of-view). These steps overall indicate two critical areas in the

reconstructed scene: (1) Expected-Empty areas (damaged areas wherein components were expected to be observed, but are not), which their identification is particularly useful for structural stability analysis and identification of structural drifts due to disaster; (2) Not Expected-Occupied areas (detected areas wherein damaged parts of the building or blockages may hinder rescue operations) which their identification is useful for rescue operation routing. By integrated representation of pre-disaster and post-disaster information, the D4AR allows the stability of the CPIs as well as possible rescue operation routings and plans to be remotely analyzed at the command center and communicated back to the field easily and quickly. Fig.2 presents preliminary results of our experiments for collecting, analyzing, and visualizing sensed data using the MWC as well as the D4AR. These results demonstrate a great potential for application of MWC and D4AR for disaster response and recovery operations. The limitation and benefits of this approach plus further required developments are discussed.

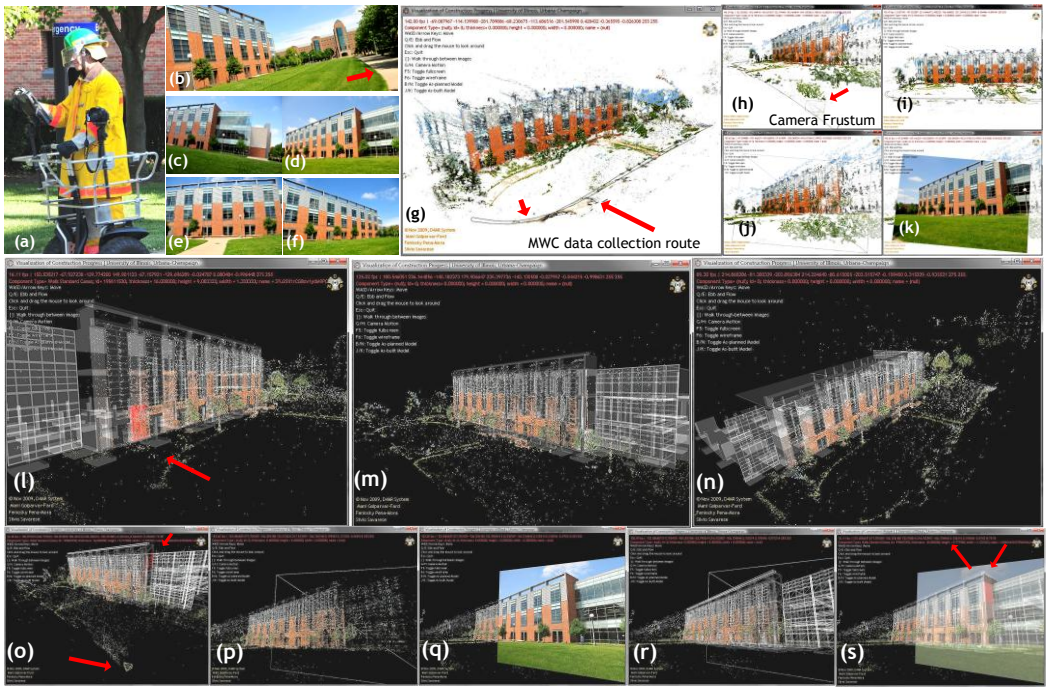

Figure 2, (a) First responder collecting images through the tablet PC mounted on the MWC. (b-f) Still images sequentially captured for reconstruction of the case study building exterior.(g-j) Reconstruction synthetic views. (k) Actual camera view registered over the reconstruction (same viewpoint with j). (l – n) Synthetic views of the D^{4}AR model visualizing *expected*, *observed* models while allowing specific BIM components be highlights and relevant information be queried. (o) A camera frustum is visualized in vicinity of the CPI. (p-r) D^{4}AR model viewed from the camera in (e). (s) BIM information queried and visualized in the upper section of the interface.

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References

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