

ARTIFICIAL INTELLIGENCE FOR REINFORCED CONCRETE BUILDING INFORMATION EXTRACTION AND RISK-INFORMED RETROFIT DECISION-MAKING

by

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Abstract

Retrofitting the critical seismically vulnerable buildings of a building inventory prior to an earthquake plays a fundamental role in the recovery of a city after a seismic event. Budgetary constraints limit the city's preemptive actions towards this impending earthquake risk such that not every building in the city can be timely inspected. Risk has typically been measured in terms of annual losses (Weatherill et al., 2015) and more recently in terms of the time it would take for a region to bounce back to the pre-event condition (Blowes et al., 2023). As evidenced by the earthquake in Nepal (2015), and the South-East earthquake in Turkey (2023), some cities may never recover (J. Karki et al., 2022 & Oduoye et al., 2023). Therefore, there is a need to develop a robust framework that can identify the critical buildings on which the city can take actions and minimize the economic losses and recovery time after a seismic event within the budgetary constraints. At the same time, buildings within the urban landscape exist in a wide spectrum of architectural forms, and function, and have city-specific challenges such as legacy detailing, and varied deterioration levels which also affect a building seismic performance. Due to the diverse nature of the urban landscape, this thesis concentrates on reinforced concrete buildings with a height of up to 6 stories that are more likely to be moment-frame buildings.

Using data-driven approaches, this thesis formulates a comprehensive framework that comprises the identification of visual characteristics, determination of vulnerability indicators and development of an optimal ranking system. The identification of reinforced concrete buildings starts with an assessment of the existing built environment using computer vision and deep learning techniques. Openly available information such as satellite imagery and street level photographs are used here to identify the building regularity, type of building, and number of stories by leveraging a novel technique, called here pose for buildings. Vulnerability indicators are calculated here from structural drawings using image segmentation. Here the main vulnerability

indicator is the Hassan Index, which has been historically used to quantify the regional seismic vulnerability inventories and to rank building (Hassan and Sozen, 1997). Then, a reinforced learning-based algorithm uses the collected building information which together with the hazard and fragility functions to rank buildings based on a reward-consequence function.

This thesis will delve into a deep learning-based framework that exploits publicly available databases of structured and unstructured data, such as images, structural drawings, and other building information, to discover optimal building rankings. This ranking will be based on the different possible actions taken by cities such as retrofits and inspections according to the degree in which these actions minimize the city's seismic vulnerability. Vulnerability indicators and metrics are selected based on their impact on the ranking's stability and robustness. Finally, this research will pave the way for comprehensive use of machine learning technologies in the context of seismic vulnerability assessment of buildings for understanding the main drivers of resistance to restoration and recovery on a regional scale.