Student Competition Paper

AI-Driven Automated Screening for Seismic Vulnerabilities in Buildings

Chedapangu Seema
Earthquake Engineering Research Centre, International institute of information technology

Project summary

Introduction

The seismic safety of existing building stocks is a paramount concern in earthquake-prone regions globally. Current visual inspection methods, as outlined in manuals like FEMA P-154, are time-consuming, subjective, and difficult to scale across vast urban areas. This project addresses this critical gap by leveraging artificial intelligence, specifically advanced computer vision object detection models, to automate the rapid visual screening of buildings for key seismic vulnerabilities. This work demonstrates a proof-of-concept for a scalable, objective, and efficient first-pass assessment tool that can prioritize structures for detailed engineering evaluation.

Problem Statement

Millions of existing buildings worldwide contain latent seismic vulnerabilities such as soft stories, short columns, and critical crack patterns. Identifying these structures manually requires a massive effort from a limited number of qualified engineers, making city-wide risk mitigation programs slow and expensive. There is an urgent need for an automated system that can rapidly analyze building imagery at scale, providing consistent and data-driven preliminary assessments to optimize the use of expert resources and enhance community resilience.

Analytical/Numerical approach

A novel dataset was curated, comprising over 1,200 images of buildings sourced from public earthquake damage databases and original field photography. Each image was meticulously annotated using bounding boxes to label specific vulnerability classes—**Soft Story, Short Column, and Diagonal Crack—** using the LabelImg annotation tool.

The YOLOv8 (You Only Look Once) object detection model was selected for its state-of-the-art speed and accuracy. The model was trained on this custom dataset using a transfer learning approach, fine tuning pre-trained weights on a GPU-enabled platform for 150 epochs. The dataset was split into 70% for training, 20% for validation, and 10% for testing. A user-friendly web application prototype was subsequently developed using the Gradio library to provide an intuitive interface for image upload and real-time analysis.

Figure 1: Manual annotation of training data using bounding boxes to label seismic vulnerabilities

Potential outcomes/ Results/ Discussion

The trained model achieved a strong mean Average Precision (mAP50) of **86.5%** on the held-out test dataset, demonstrating high proficiency in locating and classifying structural vulnerabilities. Class-specific performance was notable: **92% precision** for soft stories, **84% precision** for short columns and **83% precision** for diagonal cracks. These results confirm the viability of computer vision as a powerful tool for preliminary seismic screening.

The model successfully processes new images in real time, outputting annotated results with confidence scores, as shown in Figure 2. The primary discussion point centers on the model's role as a **force multiplier** for engineers rather than a replacement. It excels at rapidly and consistently handling large volumes of visual data, efficiently flagging potential seismic vulnerabilities for subsequent expert verification. Key limitations include its dependence on image quality and viewing angle, as well as the fact that the current model is trained on a limited dataset encompassing only common vulnerability types.
At present, the model's performance is optimized for low- to mid-rise reinforced concrete moment-frame buildings, which constitute a significant portion of the global seismically vulnerable building stock.

Figure 2 Model inference on a new image, successfully identifying and labeling a soft story vulnerability.

Conclusion

This project successfully developed a functional AI model capable of automating the first step in seismic risk assessment. The tool rapidly screens building imagery for critical vulnerabilities, offering a scalable solution for governments, urban planners, and engineering firms to efficiently prioritize resources and conduct city-wide audits. The outcomes pave the way for more resilient infrastructure by enabling proactive and data-driven decision-making.

Future work will focus on expanding the dataset to include a broader range of vulnerability classes and diverse architectural styles. Additional efforts will involve integrating the model with drone and street-view imagery APIs to enable automated, large-scale deployment, as well as enhancing accuracy through advanced model architectures such as Vision Transformers (ViTs).