

Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JAPE042

Project Title: Metaversal Historical Buildings

Project Type: Invention

*To our best knowledge, there are / are no * similar works in the market; (if there are,) related product links are as below:*

<https://www.amo.gov.hk/tc/about-us/online-articles/20220929/index.html>

The enhancement our project made / the difference with related products are:

In addition to the above product, our project has an AI system that detects surface cracks on buildings.

**Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.*

I. Background

- Provide background information as to learn about the audience for whom the project is addressing
- Provide highlights of **literature review** and/or related technologies or devices, with the support of pertinent and reliable references
- Provide an overview of work, create a point of view as to define the needs and insights of the audience and mention the **research or technology gap the project is trying to fill**

In recent years, historical buildings are being dismantled due to various reasons e.g. safety or development issues. These historical buildings are important to the society as a whole, acting as a connection to the past. They also contribute greatly to the education of teenagers, as students can learn a lot of historical facts from these buildings.

However, historical buildings often have cracks or concrete spalling, which might cause the buildings to collapse, putting the lives of citizens at risk. Therefore, it is not practical to completely ban all demolition of historical buildings. Although there are several existing methods to conserve historical buildings, these methods cannot take a balance between safety and conservation.

II. Objectives

- State the **aim(s)** of project

Our aim is to conserve historical buildings and avoid accidents caused by these buildings.

III. Methodology

- Briefly describe the **approaches** used e.g. use of equipment, materials, tests and experiments
- Explain the selected implementation strategies with the **scientific theory**

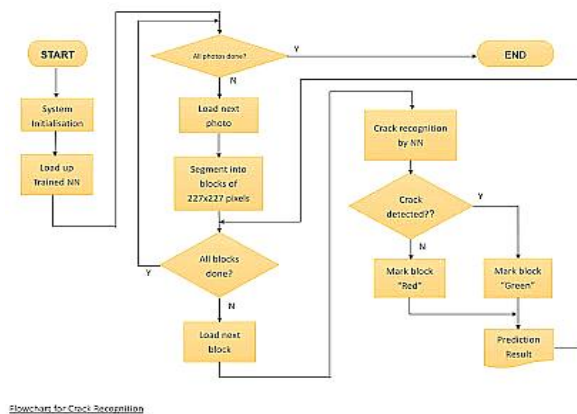
For the AI system, we have used Jupyter, Pytorch and Colab for training, processing and saving our code respectively. We chose to use Residual Neural Network (ResNet-50) for this project as it enables a much faster training of each layer and provides a lower training error percentage. To train the AI crack detection system, we used a dataset with around 20,000 images inside, including images with and without cracks. When inputted into the AI system, images are then divided into 227 x 227 pixels subunits to identify structural cracks in the images. Lastly, we used 1600 validation images to test the system and got an accuracy of 98.6%.

Meshroom is the second part of our invention. It uses point cloud technology to generate 3D models.

We decided to use Meshroom as point cloud allows it to create models with amazing fidelity, which is what we need in order to conserve the original appearances of the buildings. The models being more precise also makes it easier for the public to learn about the buildings.

IV. Design of Invention

- Describe the **design** and the **principle** of invention (e.g. The ideation of the projects, the prototypes or creative solution as far as applicable)
- Provide sketches / drawings / photos of the invention



After much consideration based on our two objectives, we have designed two main components for our project. Firstly, an AI system which helps to identify cracks on building surfaces. We originally planned to use Teachable Machine but decided to train AI ourselves for higher accuracy. Once photos are inputted, the AI will detect cracks and produce outputs marking cracks (positive) or no crack (negative).

Secondly, Meshroom is used to generate 3D models of historical buildings. After scanning the buildings from different angles with a drone, Meshroom can use the photos to produce realistic 3D models.

As our design mostly uses softwares, we do not have a hardware model for it. Above is a simple chart of how our AI system detects cracks.

V. Application / Market Need

- Explain the area of **application** and function of invention
- Indicate the market need and impact of invention
- Discuss **limitation** and compare with existing related works (if any)

With the increasing number of historical buildings dismantled, the conservation of these buildings is gaining more attention in recent years. However, both safety and conservation are equally important. We believe our invention can help in conserving historical buildings and keeping citizens safe at the same time.

The two components in our invention, AI system and Meshroom, are used to detect cracks and create 3D models respectively. Using AI, cracks in walls can be found as soon as possible, lowering the risk of accidents happening. Moreover, as cracks are common signs of concrete spalling and most structural problems, the AI can also alert people to check the damages in order to ensure concrete spalling doesn't occur. Meanwhile, 3D models can be generated using pictures of historical buildings, so that the online models created are accurate replicas of the buildings, thus conserving historical buildings digitally.

Regarding the limitations, our project cannot detect internal cracks of buildings. Therefore, we plan to incorporate infrared technology to identify internal cracks as well in the future.

Some existing methods include the Revitalising Historic Buildings Through Partnership Scheme. However, after the buildings are rebuilt under this scheme, not many people might see them as they may be located far away, the rebuild projects may also fail sometimes. As for our design, the digital 3D models can be seen by the public easily, increasing citizens' awareness of conserving historical buildings.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. (Word limit: 300 words)

With conservation and safety being main concerns in society, we believe these areas will still be important in the future. After putting AI and Meshroom together into one platform, our design can be used on a large scale. As many buildings, not limited to historical buildings, have cracks or other structural problems, we can use our system on these infrastructures, for example, hospitals and schools.

Other than simply keeping the original appearances of historical buildings, the models generated in Meshroom can be used for many different purposes in the future, for example, hold digital tours to let the public explore historical buildings online and learn more about our design.

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. (Word limit: 300 words)

Our project mainly focuses on the issue of more and more historical buildings being dismantled in recent years, a common concern among all age groups, especially teenagers and elderly. Increasing cases of accidents caused by the buildings, e.g. falling of little pieces of concrete, collapse of historical buildings, is also one of the target matters we have tried to solve.

This AI system aims to find out cracks so that the damages can be repaired as soon as possible to avoid collapse of the buildings or other major safety problems, which may lead to the knock down of these buildings. In addition, as having cracks may be a sign of concrete spalling, the system can alert people to check the area for concrete spalling if cracks are detected.

Meanwhile, the 3D models produced in Meshroom make it easier for people to learn about historical buildings, thus raising their awareness of conservation, this also ensures that the buildings can still be kept in a digital form after dismantlement. This way, historical buildings can still be conserved when facing demolition.

These two components together can solve our target social issues effectively.

VIII. Conclusion

- Make a **data-driven** conclusion of the project and the way forward of the invention process
- Justify if the proposed project meets the objective(s)

In conclusion, our project consists of an AI system and Meshroom, used to detect cracks and create 3D models of buildings respectively. With an accuracy of 98.6%, the AI system can identify most cracks on building surfaces, allowing people to fix these damages as soon as possible. This highly reduces the risk of accidents happening. We will continue to improve and develop this system.

Meanwhile, Meshroom can generate 3D models using scanings of the historical buildings. Therefore, it can conserve historical buildings digitally, ensuring that they can be known even after being dismantled. It is also easier for the public to see these online models.

In the future, we will continue improving our design, e.g. adding infrared scanning technology, putting Meshroom and the AI system into one platform. We also hope to use this invention on other infrastructures.

Our project is developed based on previous project and the enhancement is below:

N.A.