Development of an AI Rock Type Classification and Fracture State Characterization Web-based Application

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doi: https://doi.org/10.21467/proceedings.171.26

ABSTRACT

Conventional rock core logging and log checking methods, while dependable, can be labor-intensive and subjective, possibly prone to errors and inconsistencies. This project addresses these limitations by employing computer vision-based deep learning AI technology to improve the accuracy, objectivity, and productivity of rock core logging and log checking processes. A web-based application called PreLogging was developed, capable of classifying common Hong Kong rocks and decomposition grades, identifying fractures, and computing fracture state indices such as Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD), and Fracture Index (FI). The development of PreLogging involved a multidisciplinary team of researchers, engineers, and industry stakeholders collaborating to produce a tool that addresses the needs of geotechnical engineering. The development process encompassed multiple stages, including the design of a user interface, creation of an alpha version, soliciting feedback from industry stakeholders, incorporating AI computation capabilities, and releasing a stable version. The project team found that collecting feedback from industry stakeholders was crucial in ensuring the application effectively meets the industry's requirements.

1 INTRODUCTION

In the ever-evolving fields of geosciences and geological engineering, the process of rock classification serves as a cornerstone, offering indispensable information required for a wide range of applications and practices. Traditional methods of rock classification have primarily depended on the accumulated experience of experts in the field, which can inadvertently introduce a degree of subjectivity and possible inconsistencies in the classifications. To tackle this challenge and usher in a new era of objectivity, the present study endeavors to harness the cutting-edge advancements in computer vision-based deep learning and artificial intelligence (AI) technologies. The objective is to create a state-of-the-art, web-based platform, known as **PreLogging**, designed to classify both fresh and weathered igneous rocks.

In addition to its primary classification function, the PreLogging platform is also equipped to detect and identify fractures present in rock cores, as well as to derive advanced algorithms for the calculation of fracture indices. By skillfully emulating the innate human capacity to instantaneously and precisely perceive and analyze rock images, PreLogging aspires to significantly enhance the efficiency and objectivity of rock core logging and log checking processes.

Ultimately, the development and deployment of this groundbreaking tool are aimed at providing invaluable support to geologists and engineers in their quest to make well-informed decisions based on reliable and objective data. By minimizing the influence of human subjectivity in rock classification and analysis, PreLogging has the potential to revolutionize the way these professionals approach their work, thereby contributing to the advancement of the geosciences and geological engineering fields as a whole.

Proceedings DOI: 10.21467/proceedings.171; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-970666-7-2

2 WEB-BASED PLATFORM DEVELOPMENT

The initial development phase of PreLogging encompasses the creation and implementation of AI-based algorithms and logic for rock type and weathering grade classification (Tse et al., under review). This phase also includes the identification of fractures in rock cores, which will be utilized to calculate fracture indices (Tse et al., under preparation).

PreLogging boasts the ability to classify common Hong Kong rocks and decomposition grades, identify fractures, and compute fracture state indices. The platform's capabilities are as follows:

(1) Rock type prediction/identification: PreLogging supports the following major rock types in Hong Kong (1) Fine grained granite, (2) Medium grained granite, (3) Coarse grained granite, (4) Coarse ash tuff, (5) Fine ash tuff, (6) granodiorite, and (7) feldsparphyric rhyolite and (8) jar.
(2) Weathering grade prediction/identification: PreLogging supports the detection of (1) Grade II, (2) Grade III, (3) Grade IV (Core), (4) Grade V (NR), and (5) Jar.
(3) Quantitative calculation of fracture indices. PreLogging supports the computation of (1) Total Core Recovery (TCR), (2) Solid Core Recovery (SCR), (3) Rock Quality Designation (RQD), and (4) Fracture Index (FI).

Following this early-stage research, a web-based platform is developed. The development process entails the following stages:

(1) An alpha version of the app is created, prioritizing user interface and user experience design.
(2) Collaborating organizations, including the Hong Kong Geological Society and Hong Kong Construction Association – Site Investigation Committee, are invited to provide feedback on the alpha version.
(3) Based on the feedback received, AI computation capabilities are incorporated into the backend, resulting in the release of a beta version.
(4) Several supporting and collaborating organizations are invited to test the beta version. To facilitate the feedback process, an online survey form is created and utilized.
(5) User feedback is collected, and revisions are made to both the app and user manual through multiple internal trials and modifications, ultimately leading to the release of a stable version.

3 USAGE OF PRELOGGING

In this section, the PreLogging's usage workflow is depicted through a series of snapshots (Figures 1 to 11), offering a visual representation of the app's functionality. Detailed descriptions of the key steps can be found within the captions accompanying each figure. This visual guide aims to provide users with a clear understanding of how to effectively utilize PreLogging's advanced capabilities for rock core logging.

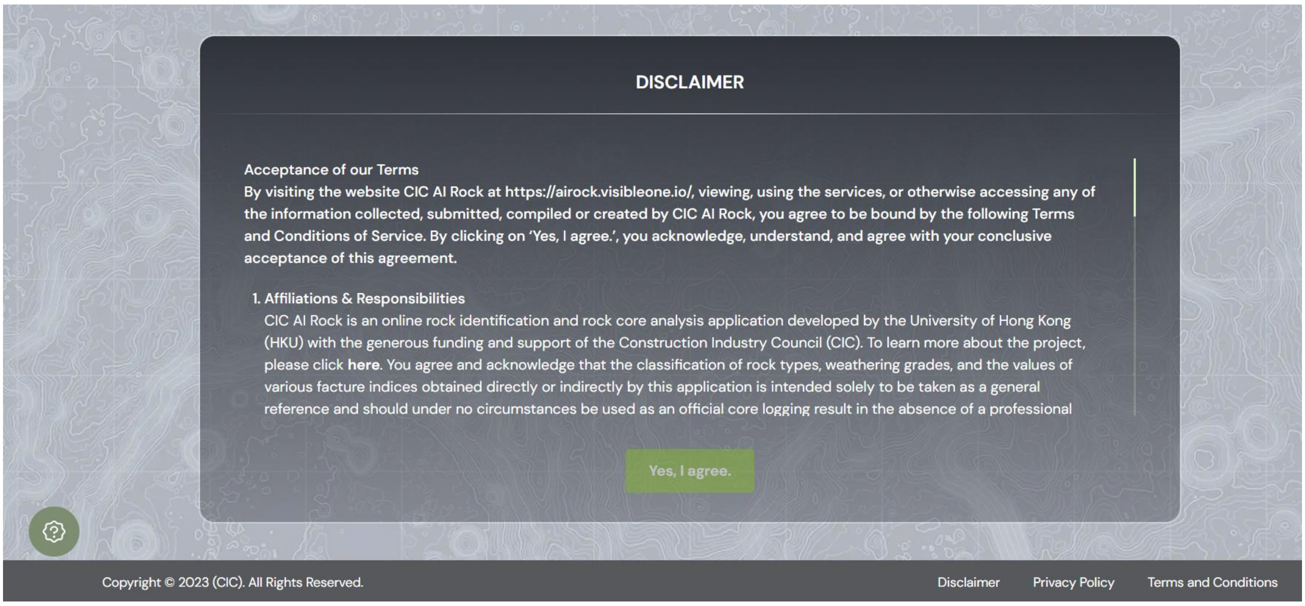

Fig. 1. Displaying disclaimer for user to click "Yes, I agree".

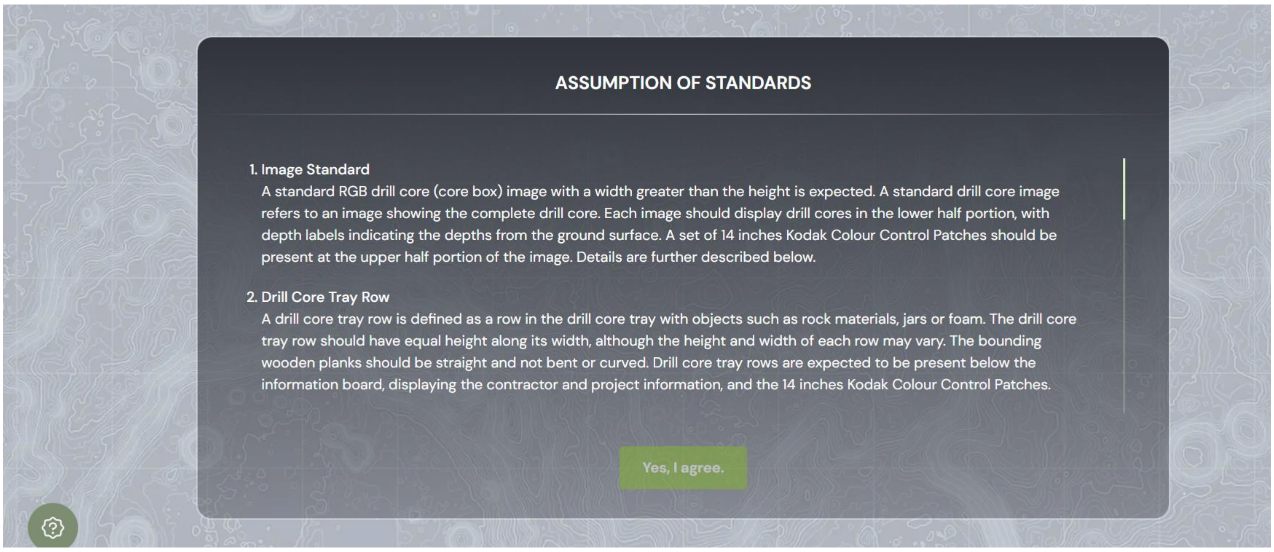

Fig. 2. Displaying assumption of standards.

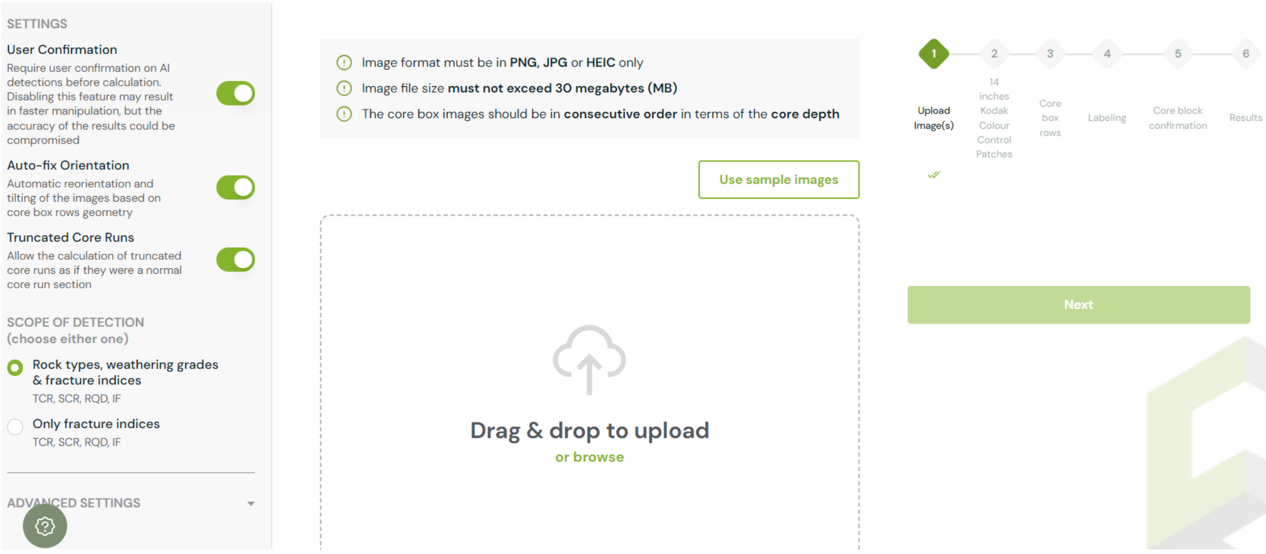

Fig. 3. Prompting user to upload a core box photograph, and to select analysis settings. A standard RGB drill core (corebox) image with a width greater than the height is expected. A standard drill core image refers to an image showing the complete drill core. Each image should display drill cores in the lower half portion, with depth labels indicating the depths from the ground surface.

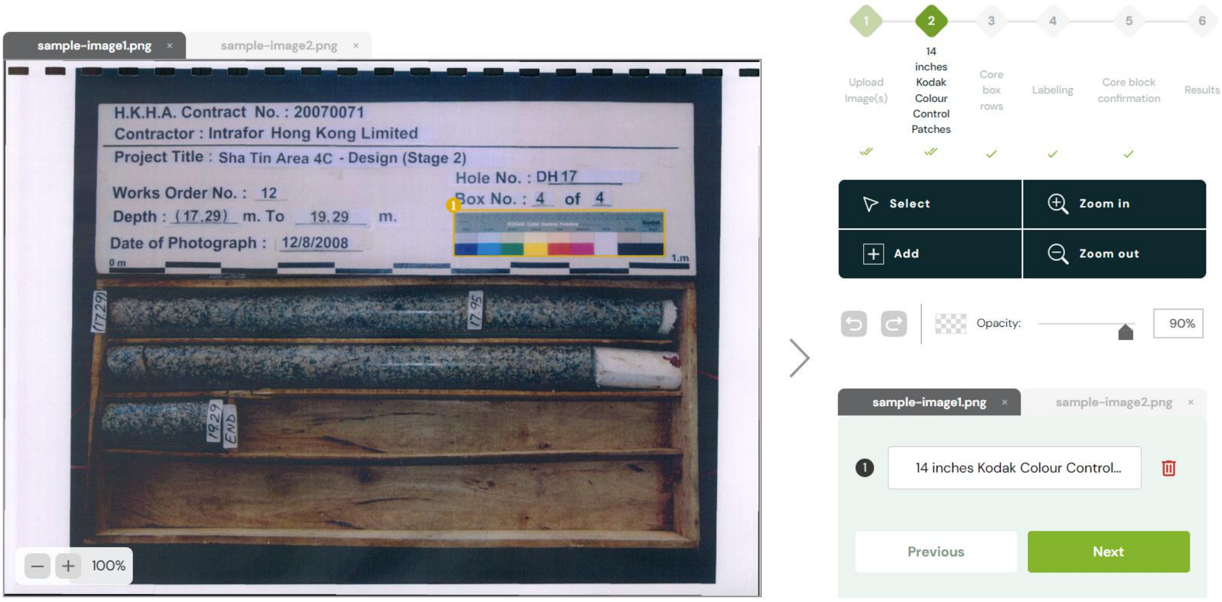

Fig. 4. Automatic identification of length scale. PreLogging takes the set of 14 inches Kodak Colour Control Patches as the length scale, which should be present at the upper half portion of the image. Smaller or non-standard Kodak Colour Control Patches may lead to incorrect calculations.

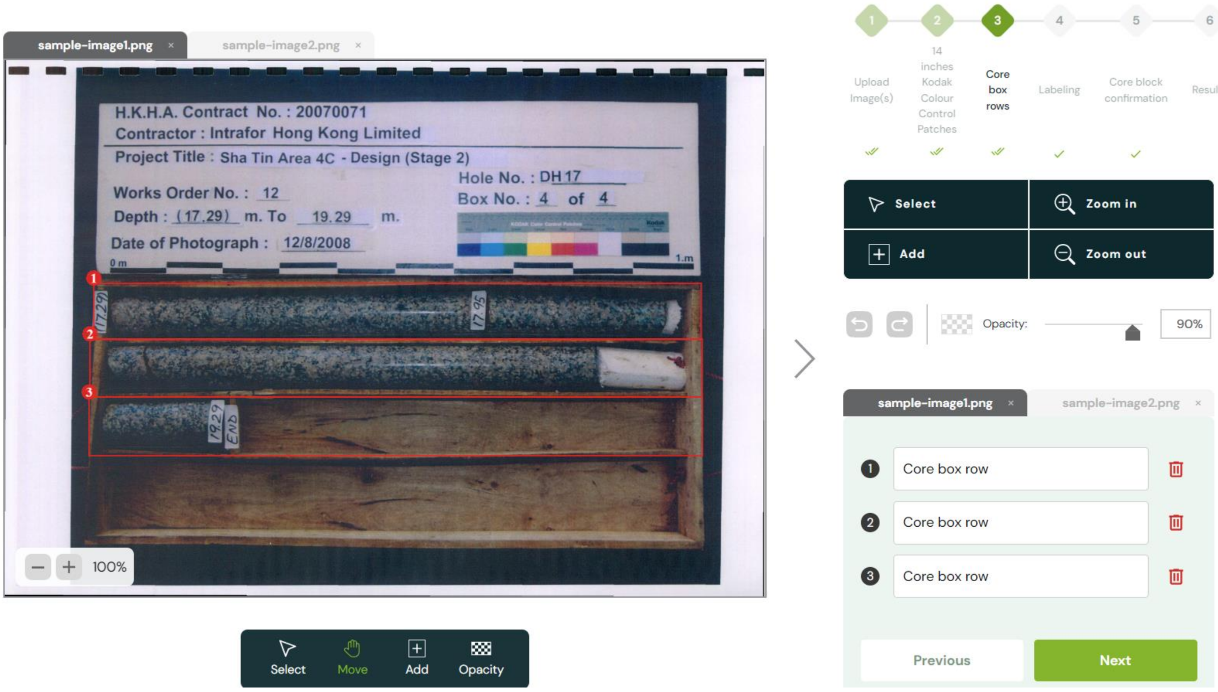

Fig. 5. Automatic identification of corebox rows. A corebox row is defined as a row in the drill core tray with objects such as rock materials, jars or foam. The drill core tray row should have equal height along its width, although the height and width of each row may vary. The bounding wooden planks should be straight and not bent or curved. Drill core tray rows are expected to be present below the information board, displaying the contractor and project information, and the 14 inches Kodak Colour Control Patches.

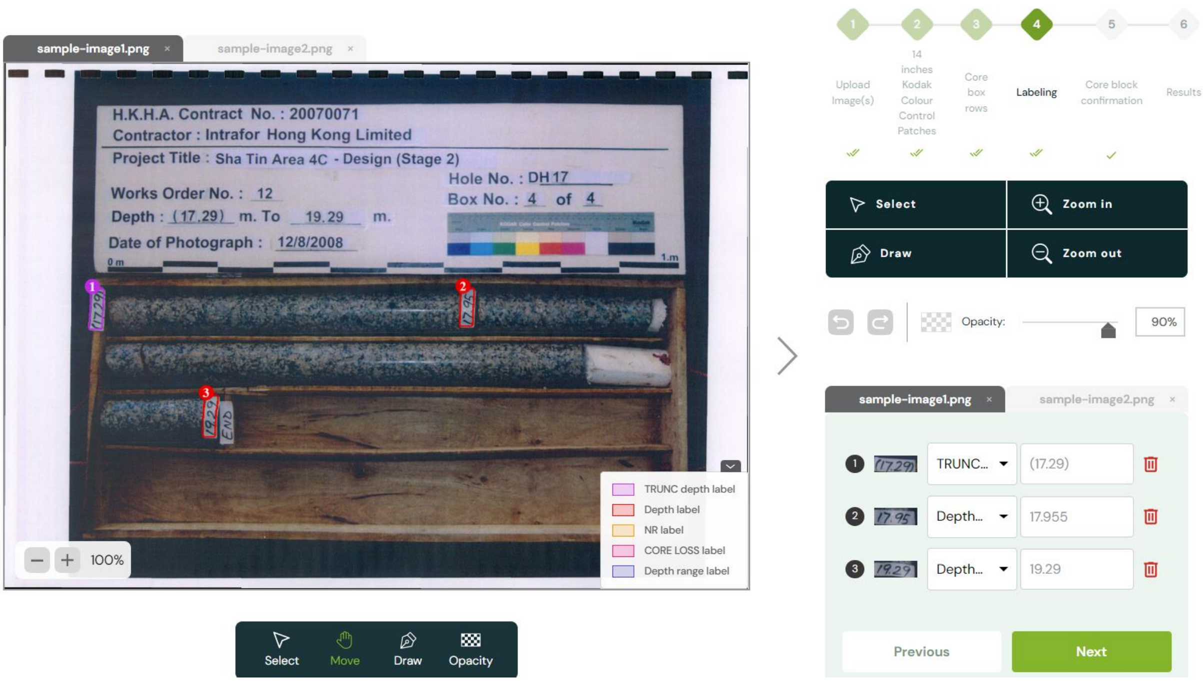

Fig. 6. Automatic identification of depth labels. Depth labels are defined as rectangular white labels displaying depth information or core conditions. The model was trained to identify a variety of hand-written depth labels, as explained below. (1) 'depth label' indicates a depth which refers to the start or end of a core run. (2) 'END label' represents the end of a drillhole. This is not required for the calculation. (3) 'CONTD label' represents that the rock core from the drillhole was put into multiple drill core trays and the drill core tray in the image only shows a portion of the drillhole. This is not required for the calculation. (4) 'TRUNC label' indicates a depth, without any specific implication. The system depends on 'TRUNC label' solely to determine the truncation of the core. (5) 'NR label' represents a section

with no recovery. (6) ‘unrelated label’ represents labels without any specific useful information to the calculation. This is not required for the calculation. Although the model can recognize 'unrelated label', it is suggested not to include them in the image. (7) ‘CORE LOSS label’ contains the same meaning as ‘NR label’, which represents a section with no recovery. (8) ‘depth range label’ indicates a range of depth which is usually used in pair with ‘CORE LOSS label’ or ‘NR label’ to indicate the no recovery range.

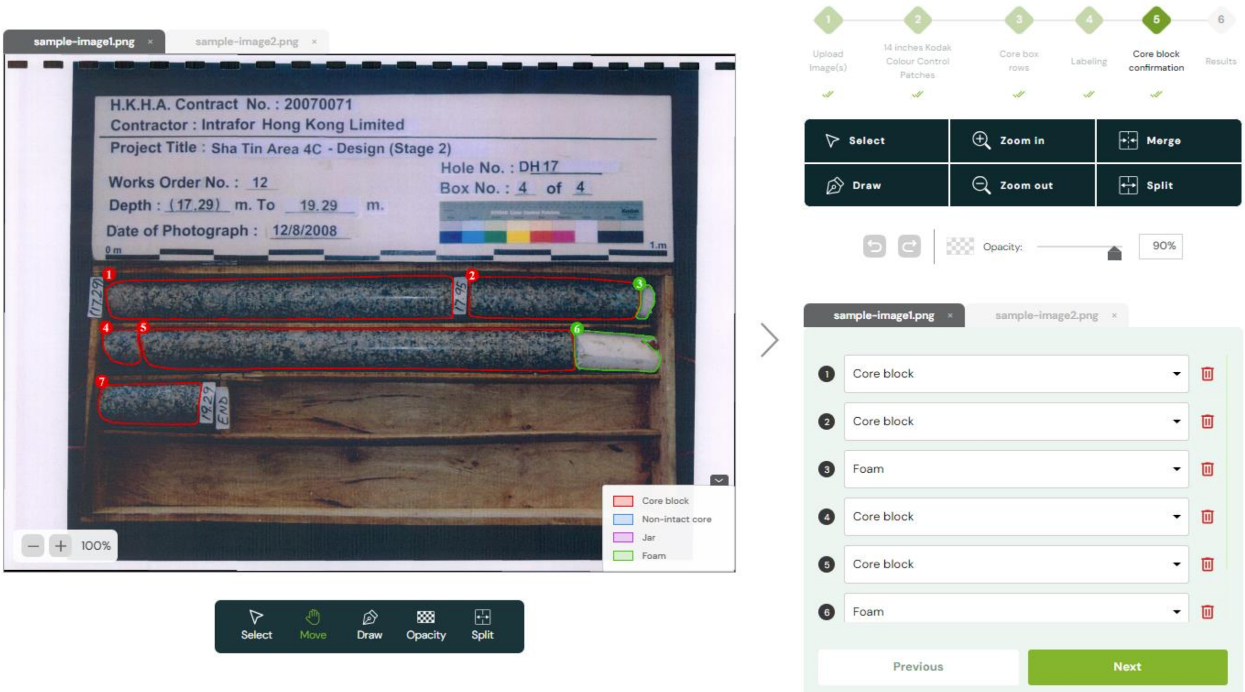

Fig. 7. Automatic identification of object types (core block, non-intact core, jar, foam).

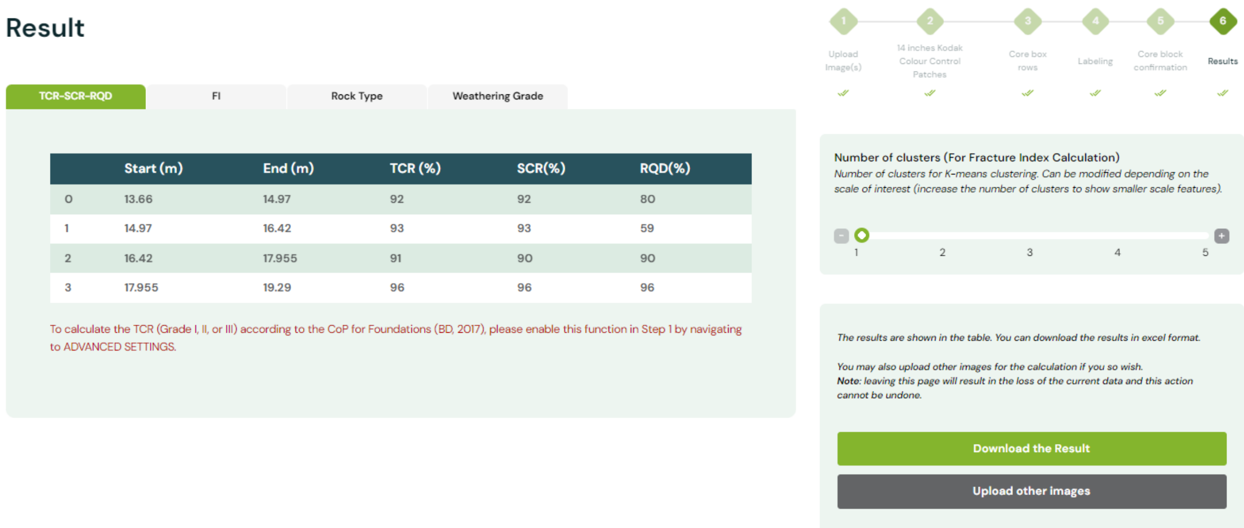

Fig. 8. Displaying results of TCR, SCR and RQD at different depths in a table format.

Proceedings DOI: 10.21467/proceedings.171
ISBN: 978-81-970666-7-2

ISSN: 2582-3922

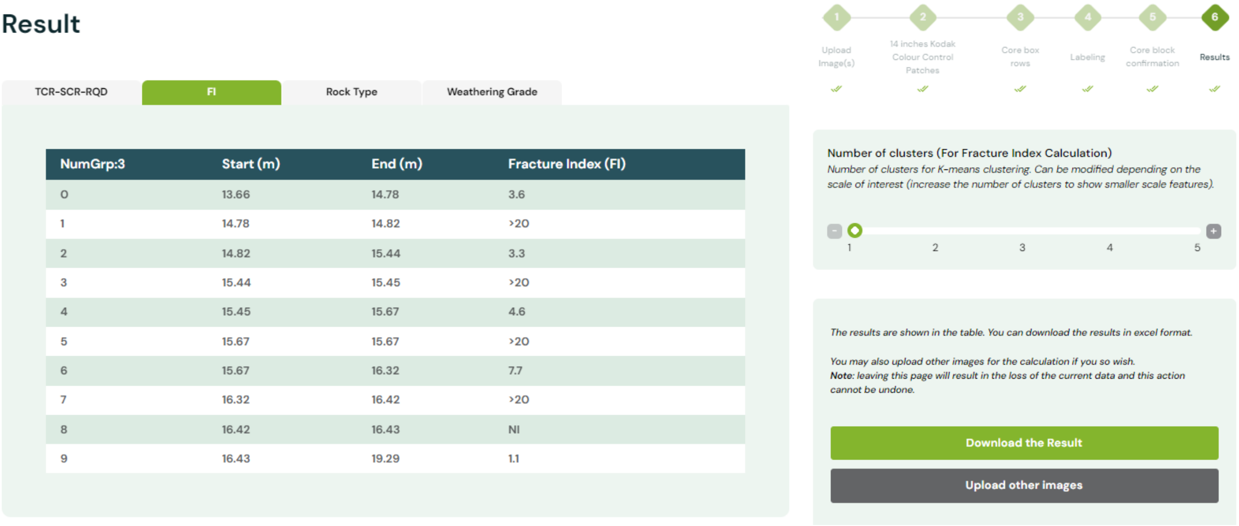

Fig. 9. Displaying results of FI (fracture indice) at different depths in a table format.

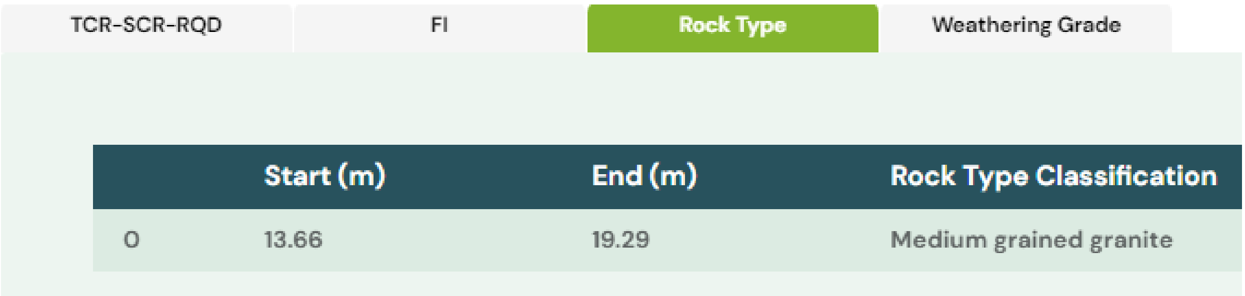

Fig. 10. Displaying results of rock type(s).

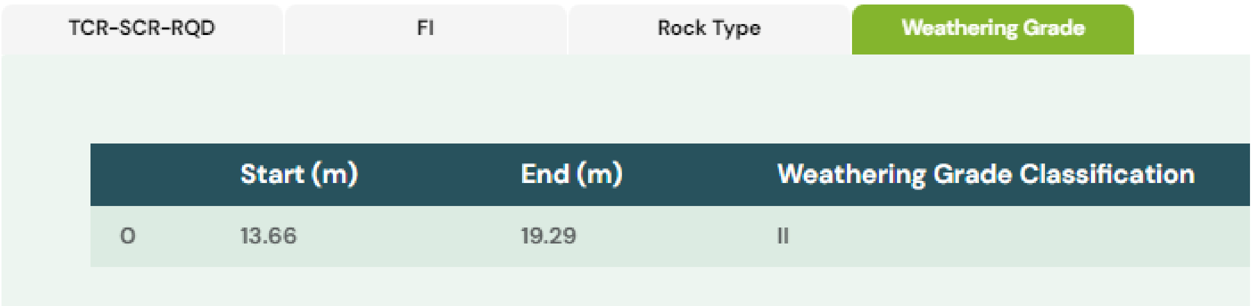

Fig. 11. Displaying results of weathering grade(s).

4 LIMITATIONS

PreLogging is a pioneering tool developed in Hong Kong to aid the ground investigation industry with logging and interpreting borelogs for the civil engineering community. In addition to core logging professionals, potential users of this tool encompass site foreman, structural engineers, civil engineers and project managers. To ensure the efficient and effective usage of PreLogging, it is crucial to acknowledge its limitations and assumptions:

1. PreLogging relies on user-uploaded corebox photographs obtained from ground investigation works in Hong Kong. Currently, the tool is not developed to handle non-corebox images or those taken outside of Hong Kong at present.
2. The predictions and calculations provided by PreLogging are not infallible. As with many AI-powered tools, users must exercise discretion when interpreting and applying the results, as they may

not be entirely accurate. This consideration is particularly critical since PreLogging's underlying principles are based on vision-oriented AI techniques applied to 2D photographs, inherently limiting predictions for concealed or unexposed features. It is important to note that PreLogging is not an X-ray tool with see-through capabilities. Nevertheless, the tool is sensitive to changes in rock types within corebox photographs. Although rock type predictions are not entirely accurate, the results can alert personnel to potential geological changes and problematic areas.

3. PreLogging has been trained using corebox photographs with varying quality levels. However, the system's performance may be compromised if the input images are of extremely poor quality, such as being blurry or having substandard content. It is essential to provide clear and accurate images for optimal results.

5 CONCLUSIONS

In conclusion, the development of PreLogging, a web-based application, has demonstrated the potential for AI and deep learning technologies to improve the accuracy, objectivity, and productivity of rock core logging and log checking processes in the geotechnical engineering field. By leveraging computer vision and AI algorithms, the application is capable of classifying common Hong Kong rocks and decomposition grades, identifying fractures, and computing fracture state indices such as TCR, SCR, RQD, and FI. The collaborative effort between researchers, engineers, and industry stakeholders has proven valuable in ensuring the application meets the requirements of the industry. However, it is important to recognize the limitations of PreLogging, such as its current inability to handle non-corebox images or those taken outside of Hong Kong, and its dependence on user-uploaded corebox photographs. The predictions and calculations provided by the tool may not be infallible, and users should exercise caution when interpreting and applying the results. The performance of the system may also be compromised by poor quality input images. Despite these limitations, PreLogging represents a significant step forward in the application of AI technology for geological engineering and has the potential to revolutionize the rock core logging process in Hong Kong.

ACKNOWLEDGEMENTS

This work was supported by the Construction Industry Council [CICR/01/22]. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Construction Industry Council. The authors also gratefully acknowledge the support from the General Research Fund (No. 17206822) of the Research Grants Council (Hong Kong). The first author acknowledges the Postgraduate Scholarship from the University of Hong Kong. A portion of the computations was conducted using the research computing facilities offered by Information Technology Services, the University of Hong Kong. Additionally, Morris Chan, Louis Ng, Calvin Wong and Derek Zhou from the Department of Earth Sciences of the University of Hong Kong offered valuable assistance in this project.

PUBLISHER'S NOTE

AIJR remains neutral with regard to jurisdictional claims in published maps & institutional affiliations.

HOW TO CITE

Wong *et al.* (2024). Development of an AI Rock Type Classification and Fracture State Characterization Web-based Application. *AIJR Proceedings*, 298-305. https://doi.org/10.21467/proceedings.171.26

REFERENCES

Tse, K.K.C., Wong, L.N.Y., Cheung, S.H. & Yu, L. under review. Advanced Classification of Drill Core Rock Type and Weathering Grade using Detection Transformer-based Artificial Intelligence Techniques. *Journal of Rock Mechanics and Geotechnical Engineering.*

Tse, K.K.C., Wong, L.N.Y., Cheung, S.H. & Yu, L. under preparation. Automatic analysis of total core recovery, solid core recovery, rock quality designation and fracture index using deep learning.