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Based on Blockchain and Artificial Intelligence Technology: Building Crater Identification from Planetary Imagery

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Abstract

Blockchain and Artificial Intelligence (AI) technology are a core force for industrial upgrading and change. Crater counting commenced with a manual enumeration of dozens, hundreds, or thousands of craters to ascertain the lifespan of geological units on planets within the solar system. Automatic crater identification methods have sought to expedite this procedure. Prior studies have utilized computer vision methodologies using manually designed features, including light and shadow trends, circle identification, and detection of edges. The study persists, with academics now employing approaches such as AI that allow the method to generate distinct characteristics autonomously. The burgeoning discipline of AI, characterized by a rapid increase in publications and methodologies, can enhance crater counting applications, mainly through collaborative multidisciplinary initiatives. The results show that integrating blockchain and AI technology can effectively promote the construction of crater detection from planetary imagery.

Keywords:

Blockchain, artificial intelligence, crater detection, intelligence.

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Introduction

In the 1970s, planet geologists recognized craters as essential for comprehending planetary development (Jones, 2024). A significant geological incident, such as a big meteorite effect, eradicates the existing surface

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geography. Researchers seek to ascertain the age of that substantial crater or another region of geographic significance. Absolute ages (on the Moon) or relative ages (on Mars and Venus) can be ascertained by quantifying the number and dimensions of craters within the geographic area (Pinti, 2023). Scholars have progressively devised several automatic Crater Identification Methods (CDA) aimed at expediting the enumeration of craters in novel regions or identifying smaller craters when better resolution information is accessible (Lee & Hogan, 2021). These automatic techniques predominantly align with contemporary computer science methodologies. Various computer vision approaches have been employed, with Artificial Intelligence (AI) approaches gaining prominence recently (Shao et al., 2022).

While craters on Mars and the Moon are detected down to 1 or 2 km throughout the surface, identifying smaller craters, particularly across extensive areas, remains a formidable challenge (Aburaed et al., 2022). When new data, particularly high-resolution data, becomes available to the scientific group, scholars reassess the surface in quest of further scientific opportunities (such as investigating supplementary craters or boulder deterioration).

In AI, data quality is pivotal for training models and making accurate decisions (Pansara, 2023). The features of blockchain technology provide reliable and tamper-proof data records, establishing a more secure and transparent data exchange mechanism, thereby creating a more robust foundation. This synergy promotes economic transformation and upgrading, ultimately improving productivity and service quality.

The growth of technology can advance the deep integration of informatization, intelligence, and networking, paving the way for industrial upgrading and transformation and enhancing production efficiency and service quality (Yu & Wang, 2021). The rapid development of new-generation information technologies, such as AI and blockchain, has dramatically reduced the barriers to the flow of information and value in digital economic activities, helping to increase the efficiency of socio-economic operations and total factor productivity, improve the efficiency of matching supply and demand, and achieve the optimal allocation of social resources.

Related Works

Blockchain Technology

- ***Fundamentals of Blockchain***

Blockchain is a decentralized database with an organic combination of multiple technologies, and each node in the chain contains the information of the entire database and maintains the consistency of the data, which mainly includes hash algorithms, digital signatures, consensus protocols, smart contracts, peer-to-peer networks, and so on (Kaur et al., 2021). Consensus algorithms enable all nodes in the entire network to complete the endorsement of the blocks.

With its unique blockchain and distributed data storage structure, combined with cryptography-related technologies, blockchain realizes the open, transparent, tamper-proof, and traceable characteristics of uplinked data. Secure data access and transmission are essential features of blockchain, and they are also the core of blockchain, which is applied to the construction to solve business pain points. Blockchain is a disruptive technology due to its ability to decentralize trust management and is considered a new generation of the cyber technology revolution. Blockchain technology has attracted attention in various fields, such as cryptocurrencies, intelligent cities, and the Internet of Things (Ali et al., 2020).

From the perspective of technology, blockchain is an Internet application technology system that integrates distributed storage, consensus mechanism, peer-to-peer communication, encryption algorithms, etc., which can realize changes in the way data are recorded, disseminated, stored, and managed and promote the transformation of the information Internet to the value Internet. From the perspective of market application, the decentralized, transparent, and difficult-to-tamper features of blockchain technically solve the trust problem and achieve disintermediation to a certain extent, thus helping to reduce the intermediation costs caused by the existence of intermediaries. In addition, blockchain can reduce commercial friction and lower the cost of trust, which can help economic activities. Figure 1 shows the blockchain consensus model.

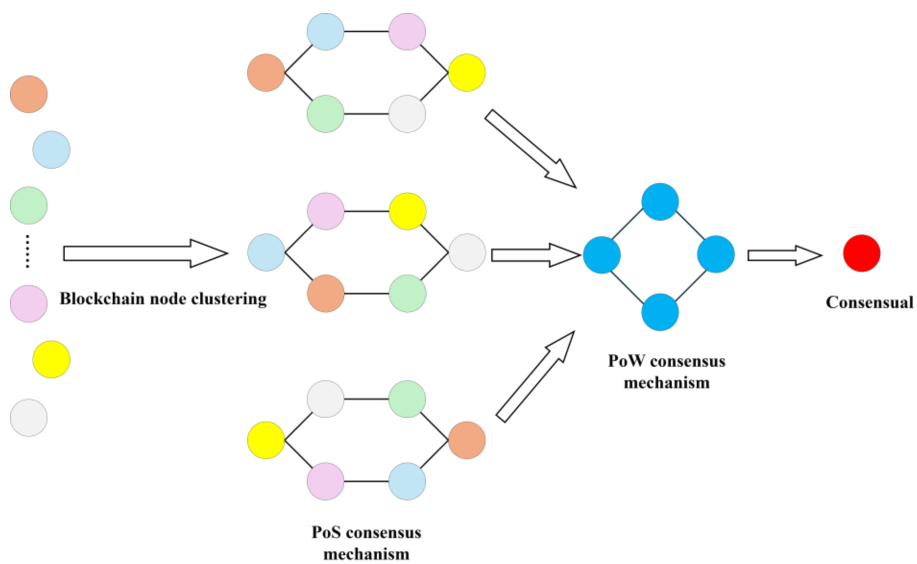

Figure 1. Blockchain consensus node principle

- ***The Evolution of Blockchain Technology***

All nodes jointly maintain blockchain data. Each node participating in the maintenance can replicate to obtain a complete record, which can achieve a set of trust mechanisms distributed in a weak trust environment without a central authority, guaranteeing that the data in the system is open and transparent, traceable, and challenging to be illegally tampered with. Blockchain has entered the scale application stage (Khan et al., 2021).

The market has yet to truly tap blockchain's innovative advantages and potential in terms of technology, concept, and model. Research and exploration on blockchain disintermediation, traceability, de-trust, co-collaboration, incentive mechanisms, and the integration and development of blockchain with other emerging technologies are still far from adequate.

Blockchain also faces various challenges that need to be overcome, including technical aspects and scenarios. Technology development is a spiral, with technology moving one step forward to promote the emergence of new value scenarios, promoting technological progress (Cunha et al., 2021). Blockchain is precisely at the stage where new compelling scenarios need to emerge, and joint exploration by the industry is crucial.

AI Technology

- ***Basic Concepts of AI***

In recent years, the development of AI technology has enabled computers to simulate human cognitive abilities and thus perform various complex tasks and decisions in place of humans (Farshidi et al., 2020). The AI research path and research content are shown in Figure 2.

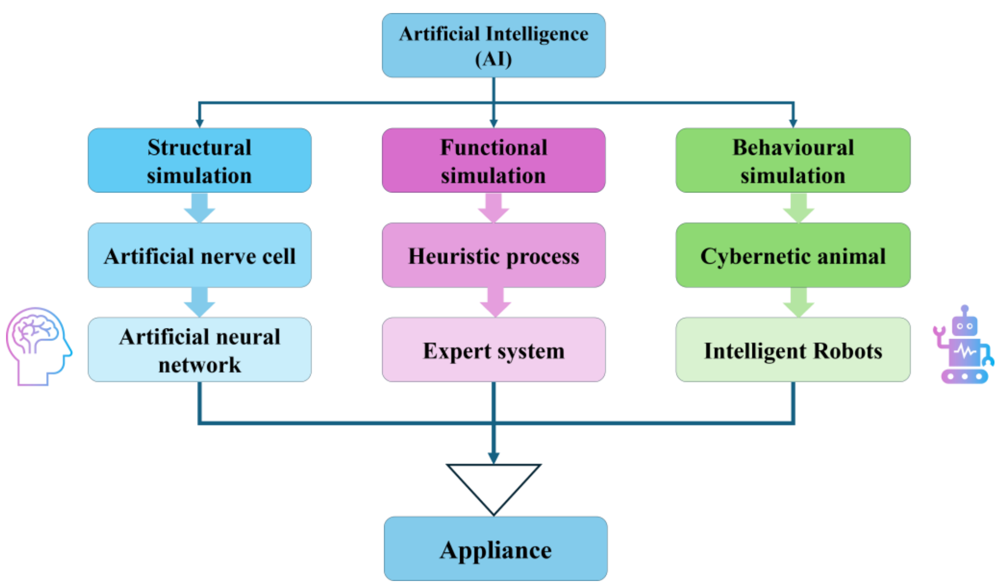

Figure 2. AI research path and research content

AI systems are mainly used to imitate human cognitive ability through computer data simulation, which includes autonomous learning, reasoning, and analytical problem solving, enabling computers to perform various complex tasks and decisions. Through continuous AI iterations, computer systems can analyze large amounts of data, identify patterns and trends, and gain knowledge to improve performance continuously. Complex reasoning and decision-making can be performed based on existing knowledge and rules to solve various problems.

Overall, the development of AI technology has enabled computers to simulate human cognitive abilities and perform various complex tasks and decisions (Nassar et al., 2020). The application of AI technology will promote the development of society towards intelligence and efficiency, and the three channels through which AI influences economic growth are given in Figure 3.

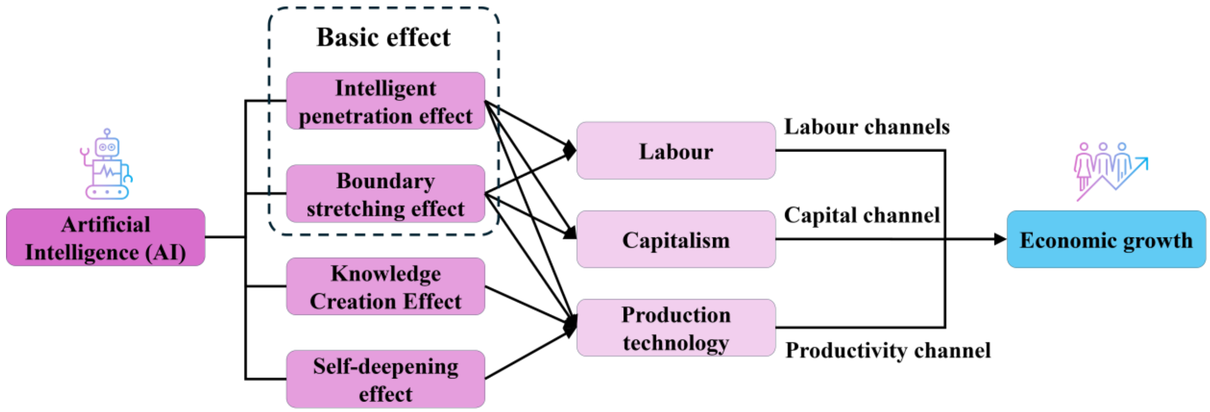

Figure 3. Three channels through which AI affects economic growth

- ***Trends in AI Technology***

AI technology is gradually changing our lives and work. It is also profoundly affecting the development. For example, natural language processing technology advances have made intelligent voice assistants, online translation, intelligent customer service, and other applications increasingly popular. When communication becomes convenient, it brings more convenience and service experience.

Humans are gradually researching AI technologies in medical diagnosis, financial risk control, intelligent manufacturing, etc., to bring about more efficient data analysis and thoughtful choices. Developing intelligent robots and automation technology will provide more efficient production and management methods in the smart manufacturing industry. AI technologies are likely to become increasingly important. There is a growing reliance on and demand for AI decision-making logic and processes. Combining AI technology and blockchain will drive towards intelligent and efficient development.

Therefore, rational application and privacy protection will become essential in building a sustainable development framework for crater detection. At the same time, these development trends will bring more intelligent, automated, and convenient development prospects.

Crater Detection Methods

Although survey studies addressing crater identification on planetary bodies have used some AI algorithms, none have yet explored the recent AI-based frameworks developed in the previous several years. Numerous prior studies evaluated various approaches to their datasets using AI methods; however, these studies predate the publications and methodologies centered on AI, which are the primary subject of this study (Silvestrini et al., 2022).

Implementing one or many CDAs across communities is a significant problem due to the variability in scientists' counting methodologies. Numerous approaches have been tailored to a specific topographical location (Chi et al., 2022). Several studies have implemented their methodology across a far more extensive and varied terrain: +30° latitude, 0-360° longitude.

This study employs AI for crater enumeration, contributing to a broader corpus of research on AI in aerospace applications. Tao et al. review Mars photos captured by the Mars Science Experiment rover Curiosity using a neural network to evaluate the scientific utility of each image (Tao et al., 2021). Fernandez-Martinez et al. employ AI to select technological advancements for asteroid deflection (Fernandez-Martinez & Sánchez-Lozano, 2021). Sigman et al. assess six classifiers for identifying debris rings (Sigman & Williams, 2020). Ikhsan et al. employ an AI to identify exoplanets inside multi-planet configurations (Ikhsan & Arifyanto, 2022). This is a brief excerpt from a recent academic study highlighting AI's significant upside in identifying patterns and its contributions to space science.

This review aims to elucidate the applications of convolutional neural networks and other AI methodologies in crater identification and enumeration while also contemplating future trajectories by examining the broader field of AI study. This study has two objectives: (1) to compile instances and assess a recent trend in the application of AI for crater calculating and AI, and (2) to furnish surroundings for both the AI and planetary geology communities to elucidate the difficulties inherent to each control.

Methodology

The suggested active AI method for crater recognition utilizes training datasets, including pictures and Digital Elevation Models (DEMs) that encompass the identical region. They were previously matched if the DEMs were produced from the photos using photogrammetric methods. Coregistration would be essential if the pictures and DEMs were obtained from disparate sources. The techniques documented in the literature apply to this objective.

The proactive AI methodology starts with a limited quantity of dynamically annotated training examples that function as the preliminary input for classifier development. Hair-like characteristics are employed to characterize the samples. An adaptable boosting technique is used to identify and amalgamate pertinent characteristics, while a cascade architecture enhances processing speed. The training method utilizes profiles obtained from the DEM to evaluate the accuracy of detection findings, which are automatically classified as accurate or wrong and categorized into positive or negative specimens accordingly.

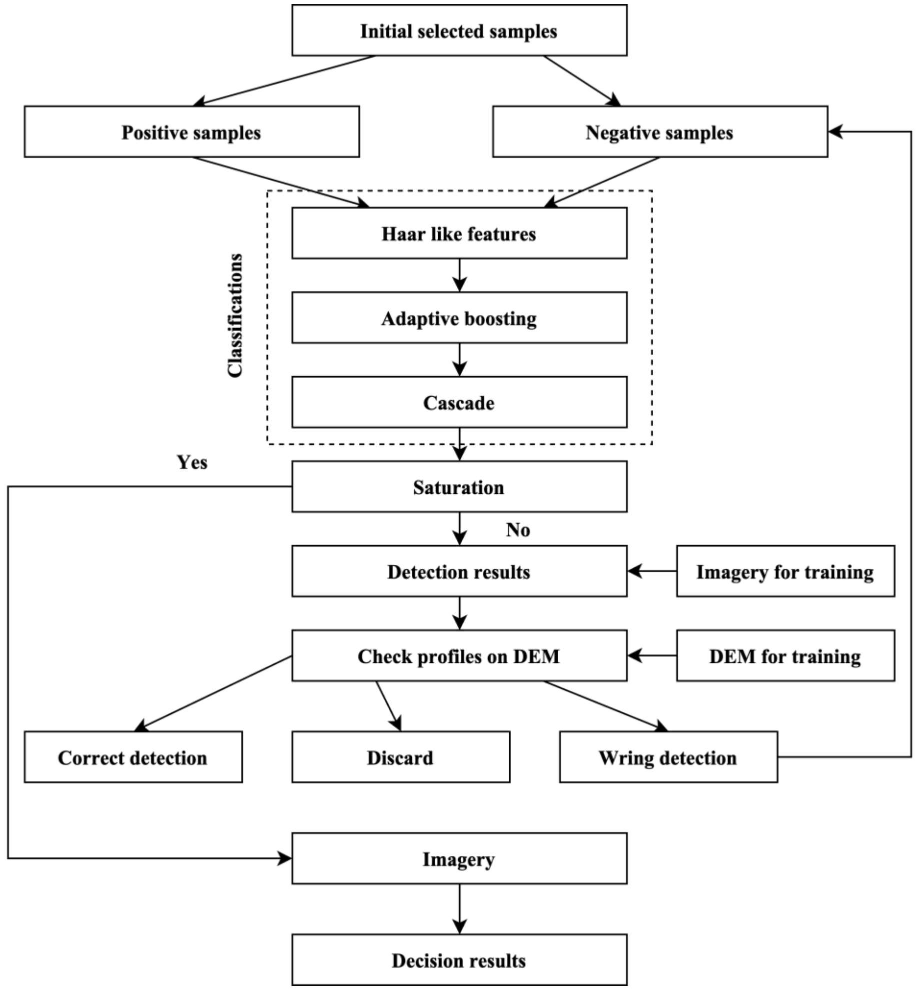

Figure 4. Architecture of the suggested model

The revised specimens will be utilized to teach and enhance the classification algorithm in AI. The cross-validation procedure will be repeated several times until saturation is achieved, indicating that further accumulation of training data will provide no additional benefit. This is proactive learning management since the system selectively chooses training examples and requests comments. Unlike traditional active education, which involves interaction with subject specialists, the 3-D data from the DEM facilitates the selection and labeling of both beneficial and detrimental instances. After that, the resulting classifier is utilized on 2-D photos in various domains for crater identification. Figure 4 illustrates the structure of the suggested methodology.

Utilizing the final output classification from the phases above, crater identification is performed on photos from different regions. Each input picture rotates based on the sun orientation of the image to align the lighting direction with that of the trained examples. A picture pyramid is constructed at numerous scales to identify impact craters of varying sizes, which is subsequently analyzed by the classification. The identified outcomes from every stage are consolidated into the outcome. The identification result comprises a series of squares with data regarding position and dimensions. The most enormous, engraved circle of the square delineates the perimeter of the identified craters. No DEM is utilized in the detecting phase. The training method for every database only needs to be performed once, allowing the classification to be used on further untrained images.

Blockchain and AI Technology Convergence Applications

As the benefits of blockchain and AI come to the fore, people ponder whether they can merge them to achieve more significant potential. The research and application of blockchain and AI technologies rely on large amounts of accurate data. Among other things, blockchain needs to ensure the integrity and consistency of data. And the accuracy of AI algorithms also depends on the amount of data. In addition, blockchain technology helps to improve data collection, storage, and processing in AI applications.

However, in this competitive society, it is difficult for small and medium-sized AI companies to access data, and it is more challenging to scale up their business. Blockchain technology aptly solves this problem using peer-to-peer connections, enabling SMEs to access accurate data. In terms of data storage and processing, using blockchain's distributed data storage method can accelerate the training of AI algorithms, improving the model of centralized data storage and computing. In addition, blockchain's value chain nature helps solve the problem of standards and sharing of AI algorithms, avoiding the infringement of intellectual property rights through paid sharing and enabling companies to collaborate efficiently. Finally, introducing AI can improve the consensus mechanism and smart contracts of the blockchain, making the blockchain more autonomous and intelligent.

AI and blockchain can collaborate to realize complementary advantages. The application architecture of blockchain-integrated AI is based on data, algorithms, and arithmetic. It utilizes blockchain's value and hard-to-tamper characteristics to achieve encryption, pricing, evaluation, and data trading to build trusted data. The underlying framework logic of AI technology and blockchain technology is given in Figure 5. The intelligent algorithm layer realizes the disassembly, invocation, and sharing of general intelligent algorithms of AI while using the arithmetic sharing of blockchain to solve the arithmetic shortage problem faced by the AI industry. The efficiency of the blockchain is further improved through mining arithmetic, intelligent optimization, intelligent consensus, and intelligent contracts.

The development of "blockchain + AI" will significantly promote the formation of digital industrialization, i.e., the development of the information and communications industry (including telecommunications, software, and other information technology services as the core industry), and then promote the formation. For example, the distributed network, asymmetric encryption, consensus mechanism, smart contract, and decentralization in blockchain application can achieve comprehensive application in several industrial fields such as digital currency, supply chain coordination, quality traceability, e-government, intelligent manufacturing, etc., and achieve comprehensive digitization and mechanization of the application of blockchain technology through the mechanism of AI, and then form a more comprehensive digital industry chain to support the comprehensive development.

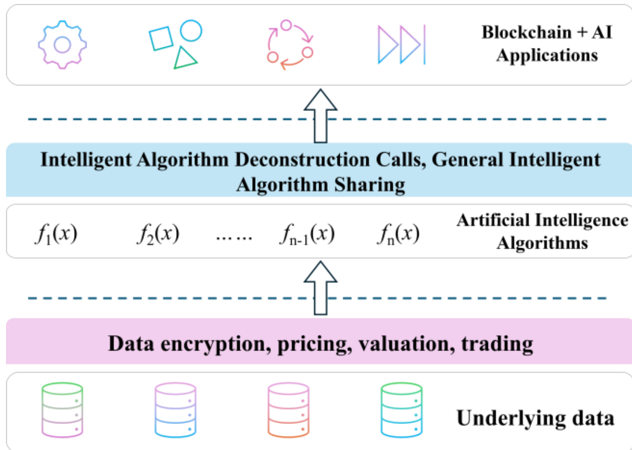

Figure 5. Underlying framework of AI, blockchain technology

Blockchain and AI Technology Convergence and Empowerment

AI applications can be categorized into three key points: data, algorithms, and computing power. When blockchain and AI are fused, they can empower each other and provide more possibilities, and Table 1 shows the fusion empowerment points of blockchain and AI technology. In terms of data, blockchain technology can ensure the trustworthiness of data and enable data sharing while protecting data privacy, providing high-quality data for AI modeling and applications to improve the accuracy of models. In other words, blockchain provides a more reliable data source to make AI models more accurate. In terms of algorithms, a blockchain's smart contract is essentially a piece of code that implements a specific algorithm, which can be made brighter by integrating AI technology.

Blockchain can ensure that the models and results of AI engines are not tampered with, reducing the risk of human attacks on the models. Finally, in terms of computing power, blockchain-based AI can realize decentralized intelligent joint modeling and provide users with elastic computing power to meet their computing needs. This means that the combination of blockchain and AI can provide users with more flexible computing power and meet their needs in AI. Such cooperation makes AI technology smarter and provides users a more reliable database, improving models' accuracy.

Table 1. Blockchain and AI technology convergence enabling points

	Blockchain	AI	Convergence
Data	Assurance of data credibility Protecting data privacy	Need for high-quality data modelling Need for multi-dimensional data	Blockchain Provides Trusted Data for AI to Ensure Data Security
Algorithms	Smart contracts are not smart Smart contracts are inflexible	Helps resume smart contract code	AI Helps Enable Intelligent Smart Contracts
Computing power	Decentralized distributed structure Tamper-proof	High cost of centralized arithmetic Code vulnerabilities are easily compromised	Blockchain Distributed Architecture Provides Distributed Arithmetic for AI

The real significance of blockchain, as an essential technology emerging from the fourth industrial revolution, lies in the transmission of value. The previous Internet only completed the transmission of information, while the transmission of value has a more profound meaning. Blockchain and AI are both popular new-generation information technologies with broad development prospects. Both can provide adequate technical support for the continuous progress of social production and life and offer an essential impetus for accelerating high-quality development. Blockchain can establish trusted data storage and management based on distributed collaboration. At the same time, AI can motivate human beings to optimize the effect of data and knowledge acquisition; the integration of the two developments and applications will ensure the impact of data and knowledge acquisition, management, and use under distributed collaboration and will also be the inevitable trend of future development, it is essential and meaningful to study and explore the relationship between them.

Results and Discussion

This research chose two test datasets that exemplify the general properties of the lunar and Martian surfaces. The identification and assessment zones encompass a variety of dimensions and kinds of craters. The digitally digitized real-world crater inventory derived from the photos was utilized for elevation analysis. The research concentrated on craters with sizes above 20 pixels in the images to ensure validation efficiency. Manual tagging was conducted using a 20-pixel referencing grid superimposed on the picture to denote crater size. Two managers independently cataloged actual truth information to ensure trustworthiness, and the outcomes were amalgamated. Craters recognized by a single operator were subsequently verified. The study for the lunar dataset utilized the SELENE pictures and the SLDEM. The SLDEM was generated by combining the DEM from SELENE pictures with data from the Lunar Orbiter Light Altimeter, resulting in a successful resolution in the space of 60 meters. Two distinct datasets from separate places were used for training and assessment purposes.

Figure 6(a) presents a SELENE TC picture with a resolution of 10 m/pixel, whereas Figure 6(b) displays the coregistered SLDEM. Both were utilized for training objectives. A different SELENE TC picture (Fig. 6(c)) was used for crater discovery and assessment. The landscape is characterized by several craters that are next to or overlap one another.

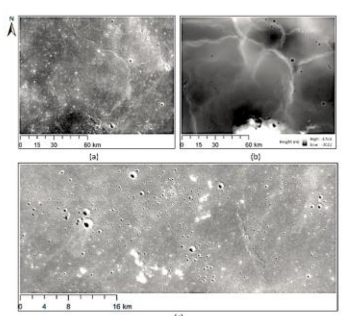

Figure 6. Lunar dataset analysis

The proactive AI methodology started with 130 positive and 300 negative observations utilized as inputs for classification training, designated as the initial round. The classification was subsequently employed to identify craters in the picture for training objectives. Profiles were derived from the coregistered DEM for each detecting outcome. The judgment rendered by the individuals automatically classified the outcome as accurate or erroneous and then categorized it into either of those categories accordingly. The recently produced affirmative samples.

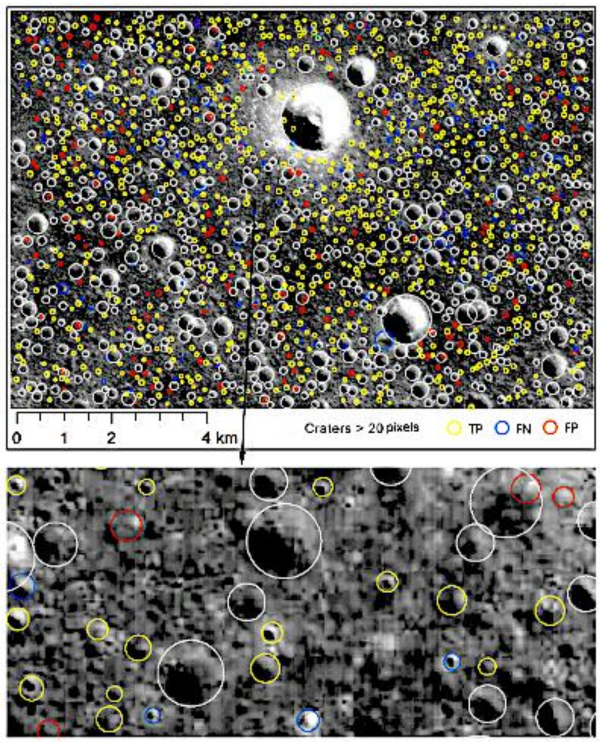

Figure 7. Crater detection analysis

The investigations for the Mars dataset utilized High-Resolution Stereo Camera (HRSC) photos and DEMs obtained from HRSC imagery. Like the studies on Lunar information, two datasets from separate places were chosen for training and assessment—the survey of the Mars information adhered to the same methodology as that utilized for the moon information. The process of active AI commenced with 200 positive samples and 600 negative specimens, ultimately resulting in over 5000 specimens in total. The efficacy of the detection classification progressively enhanced with the accumulation of training specimens until convergence occurred after the fifth cycle, achieving a True Detecting Rate (TDR) of 93.6% and a False Detecting Rate (FDR) of 4.12%.

Figure illustrates the 1300 verified craters, whereas Figure depicts the 1200 identified craters. Figure illustrates the comparison between the ground reality and the identification outcomes obtained by the classification in cycle 5. Yellow circles represent true positives, blue circles denote false negatives, and orange circles indicate false positives.

Conclusion

Examining sensor and picture data offers significant collaborative potential for AI academics and planetary researchers. Planetary scholars can offer their extensive expertise in datasets and structuring intricacies. They can enhance cooperation by selecting the most suitable benchmark databases for method comparison. Experts in AI can provide specialized knowledge in picture transformation. Techniques like segmentation and positioning have been thoroughly advanced within that field and are relevant to planetary research. Individuals seeking to contribute their research to the planet's scientific community exports their crater listings in codecs compatible with widely utilized crater assessment tools, such as JMARS (for validating the crater listing) and Craterstats (for age determination).

The development and advantages of combining blockchain and AI are increasingly receiving widespread attention. They are widely used in information sharing, security and confidentiality, supervision and transparency, traceability and authentication, and trust and collaboration. Blockchain+AI technology will help realize effective sharing of global high-quality information resources and data encryption, as well as better supervision and inspection, and promote openness and transparency. This will facilitate more targeted online transactions, matchmaking platforms, and authentic social networks. The combination of the two will help to enhance their respective technological levels, fully explore their technological potential, and actively promote intelligence to support and safeguard the development of more fields.

The current trend of utilizing pre-trained systems might not be the optimal solution; however, once a group reaches a consensus on standardized compare comments for training, importing outcomes to the forms of widely used age-dating initiatives and collaborating with a human intermediary remains the most effective short-term approach. Partnerships among planet geologists and AI specialists will significantly advance crater detection methodologies.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

References

Aburaed, N., Alsaad, M., Mansoori, S. A., & Al-Ahmad, H. (2022). A study on the autonomous detection of impact craters. In *IAPR Workshop on Artificial Neural Networks in Pattern Recognition*, 181-194.

Ali, R., Qadri, Y. A., Zikria, Y. B., Al-Turjman, F., Kim, B. S., & Kim, S. W. (2020). A blockchain model for trustworthiness in the internet of things (IoT)-based smart-cities. *Trends in cloud-based IoT*, 1-19.

Chi, J., Wang, M., Chen, J., Hu, L., Chen, Z., Backman, L. J., & Zhang, W. (2022). Topographic orientation of scaffolds for tissue regeneration: recent advances in biomaterial design and applications. *Biomimetics*, 7(3), 131. https://doi.org/10.3390/biomimetics7030131

Cunha, P. R. D., Soja, P., & Themistocleous, M. (2021). Blockchain for development: a guiding framework. *Information Technology for Development*, 27(3), 417-438.

Farshidi, S., Jansen, S., España, S., & Verkleij, J. (2020). Decision support for blockchain platform selection: Three industry case studies. *IEEE Transactions on Engineering Management*, 67(4), 1109-1128.

Fernandez-Martinez, M., & Sánchez-Lozano, J. M. (2021). Assessment of near-earth asteroid deflection techniques via spherical fuzzy sets. *Advances in Astronomy*, 2021(1), 6678056. https://doi.org/10.1155/2021/6678056

Ikhsan, M. I., & Arifyanto, M. I. (2022). Exploring multi-planet system wasp-148 using n-body simulation and deep learning. *In Journal of Physics: Conference Series*, IOP Publishing, 2243(1). https://doi.org/10.1088/1742-6596/2243/1/012010

Jones, R. H. (2024). Meteorites and planet formation. *Reviews in Mineralogy and Geochemistry*, 90(1), 113-140.

Kaur, S., Chaturvedi, S., Sharma, A., & Kar, J. (2021). A research survey on applications of consensus protocols in blockchain. *Security and Communication Networks*, 2021(1), 6693731. https://doi.org/10.1155/2021/6693731

Khan, D., Jung, L. T., & Hashmani, M. A. (2021). Systematic literature review of challenges in blockchain scalability. *Applied Sciences*, 11(20), 9372. https://doi.org/10.3390/app11209372

Lee, C., & Hogan, J. (2021). Automated crater detection with human level performance. *Computers & Geosciences*, 147, 104645. https://doi.org/10.1016/j.cageo.2020.104645

Nassar, M., Salah, K., ur Rehman, M. H., & Svetinovic, D. (2020). Blockchain for explainable and trustworthy artificial intelligence. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 10(1), e1340. https://doi.org/10.1002/widm.1340

Pansara, R. (2023). Cultivating Data Quality to Strategies, Challenges, and Impact on Decision-Making. *International Journal of Management Education for Sustainable Development*, *6*(6), 24-33.

Pinti, D. L. (2023). Absolute and Relative Ages. In *Encyclopedia of Astrobiology*, 38-40.

Shao, Z., Yuan, S., Wang, Y., & Xu, J. (2022). Evolutions and trends of artificial intelligence (AI): research, output, influence and competition. *Library Hi Tech*, 40(3), 704-724.

Sigman, M. E., & Williams, M. R. (2020). Chemometric applications in fire debris analysis. *Wiley Interdisciplinary Reviews: Forensic Science*, 2(5), e1368. https://doi.org/10.1002/wfs2.1368

Silvestrini, S., Piccinin, M., Zanotti, G., Brandonisio, A., Bloise, I., Feruglio, L., & Varile, M. (2022). Optical navigation for Lunar landing based on Convolutional Neural Network crater detector. *Aerospace Science and Technology*, 123, 107503. https://doi.org/10.1016/j.ast.2022.107503

Tao, Y., Conway, S. J., Muller, J. P., Putri, A. R., Thomas, N., & Cremonese, G. (2021). Single image super-resolution restoration of TGO CaSSIS colour images: Demonstration with perseverance rover landing site and Mars science targets. *Remote Sensing*, 13(9), 1777. https://doi.org/10.3390/rs13091777

Yu, X., & Wang, P. (2021). Economic effects analysis of environmental regulation policy in the process of industrial structure upgrading: Evidence from Chinese provincial panel data. *Science of the Total Environment*, 753, 142004. https://doi.org/10.1016/j.scitotenv.2020.142004