

Invited Lecture

Artificial Intelligence and Citizen Science

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●What is citizen science?

Citizen science is the collection of scientific data with the help of the general public. Volunteers, known as “citizen scientists,” participate in collaborative research by collecting data and recording observations for scientific projects. These projects cover a wide range of topics, from observing wildlife behavior to measuring air quality, and have often provided valuable data that researchers can use to solve pressing environmental and social issues.

Participants in citizen science projects generally follow the same protocols. This ensures that all participants collect data using the same procedures, resulting in high-quality, consistent data. Additionally, all stakeholders have access to the generated data. Access to the data and the knowledge derived from it is a fundamental premise of citizen science. From this perspective, it is easy to see the strong connection between citizen science and open science.

●The Significance of Citizen Science

Citizen science involves the general public in the world of science, enabling them to participate in data collection, analysis, and even project design. This approach generally offers the following three advantages.

- ① Increased data collection: By involving a wider audience, citizen science projects can collect vast amounts of data over a broader geographical area and a longer period of time.
- ② Diverse Perspectives: Citizen scientists bring unique perspectives to research and may uncover patterns or trends that professional researchers might overlook.
- ③ Public Engagement: Citizen science fosters public interest in science and promotes scientific literacy within communities.

Large-scale platforms such as Galaxy Zoo and eBird allow volunteers to classify galaxies and identify bird species, contributing to groundbreaking research. These projects not only generate valuable data but also encourage citizen engagement in science.

One of the great things about citizen science is its accessibility. Anyone can participate, regardless of age, background, or expertise. There are roles for everyone, from taking photos of plants and birds to recording weather patterns. By harnessing the collective power of diverse perspectives and experiences, citizen science not only accelerates scientific progress but also fosters a sense of community and shared responsibility for the world around us. Citizen science empowers communities, deepens knowledge, reveals answers, and contributes to true discovery. As we face global challenges, it is essential to find community-based methods that have a positive impact on local societies. Whether it is the protection of native plants and animals or the protection of water sources, depending on the scale of these issues, more eyes, ears, and unique perspectives may be needed than a single scientist can provide. By leveraging the power of citizen science, we can encourage citizen participation and focus research issues on the needs of local communities. More

importantly, citizen science democratizes access to data and provides participants with the tools to conduct their own research and make decisions.

The appeal of citizen science lies in its ability to leverage the collective knowledge and enthusiasm of a vast volunteer network. By tapping into this global pool of talent, researchers can collect vast amounts of data that would otherwise be impossible or prohibitively expensive to gather. This data often spans vast geographical areas and long time periods, providing valuable insights into complex phenomena such as climate change, biodiversity loss, and disease outbreaks.

Citizen science projects serve as a powerful platform for public education and outreach, bridging the gap between science and society. By engaging citizens in practical scientific research, these projects dispel misconceptions about science and foster a more scientifically literate citizenry.

- Recent developments in citizen science and digital devices

Before discussing recent examples of citizen science, it is important to note that the advent of digital devices has greatly advanced citizen science.

Digital devices such as smartphones are ideal for citizen science initiatives because they allow users to access location information, dates, and times when taking photos, as well as take notes and access the internet. This has made it easier than ever for the general public to participate in scientific discoveries, experiments, data collection, and analysis.

For example, suppose a citizen scientist is observing seasonal flowers in a state park. They take a photo of a rare orchid. The photo includes the flower, its surroundings, a timestamp, and tagged location information. The citizen scientist can add notes to the photo and instantly upload the data to the internet.

Historically, when professional scientists wanted to collect more information, they used existing networks of amateur groups such as birdwatchers. With the widespread availability of the internet in the late 1990s, it became easier for people to share and provide information, leading to an increase in the number of citizen science programs. New networks and communities of interested citizen scientists are being created on a daily basis. In the future, more smart sensors will be installed in smartphones, enabling them to measure and record environmental data such as air quality and temperature.

Citizen science projects can be utilized for various purposes, including monitoring environmental changes, tracking the spread of invasive species, and studying the impact of urbanization on wildlife. Many citizen science projects utilize online platforms and mobile apps to enable participants to easily submit their observations and data.

- Types of Citizen Science

There is no single way to utilize citizen science. While there is no universal method that applies to all projects, citizen science projects can generally be divided into following four categories. The nature of the project determines the appropriate level of participant involvement and the stage of the research process at which they should be involved.

- ① Participatory Citizen Science:

This citizen science model has the lowest level of participant involvement among the four categories. Participants are mainly involved in data collection. For example, in bird watching or air quality monitoring, the general public observes and collects data on specific themes. Suppose there is a smartphone app that allows citizen scientists to count and share the number of certain species of earthworms they have observed. In this example, participants are not involved in the development of the project or methodology, but they are actively involved in collecting data that can be used as part of the research project.

② Collaborative Citizen Science:

This category is characterized by a higher level of involvement throughout the research process than participatory citizen science. Typically, these types of projects are designed by researchers, but they may also be improved by participants. Participants may also collaborate in analyzing and disseminating information. For example, in some projects described later, citizen scientists not only collect data but also provide input on the tools and methods used.

③ Co-creation citizen science:

This model involves the highest level of participant involvement. Citizen scientists are involved in the entire process of co-creating knowledge, including protocol development and data analysis. Collaborative projects are particularly effective when community issues are involved and researchers want to collect data that could lead to policy changes. An example of this type of project is a project in which citizen scientists are involved in each stage of an interdisciplinary research project (Raising issues, collecting data as part of knowledge co-production, and implementing knowledge in the community).

④ Citizen-led citizen science:

This is a project in which citizens themselves invent, design and lead the project, with scientists involved as advisers and collaborators as needed. Citizen-led initiatives can be seen in cases where residents who are victims of environmental destruction or pollution ask scientists or NPOs with scientific expertise to cooperate, set up an investigation group, collect scientific evidence and data, clarify the actual conditions and causes of the damage, and demand countermeasures and compensation from the offending companies and the government.

● Conditions for the success of citizen science

Three important elements are essential for the success of citizen science projects.

- ① The first is access to experts. Not only experts, but also experts who are willing to respond to the needs of citizens are necessary. Without the willingness of both parties, nothing will happen.
- ② In addition, material resources are also necessary. Without connections to important stakeholders and the resources necessary for the success of the project, the project will remain nothing more than an idea.
- ③ Finally, open access information (such as publication or website dissemination) is necessary. This is probably the most important means of informing citizens about ongoing issues. An informed citizen is more motivated to change.

● Recent Trends

As awareness of citizen science grows, several new trends are emerging.

- ① Increased use of technology: Citizen science projects are increasingly utilizing technology such as online platforms, mobile apps, and sensors, making it easier for the general public to participate and submit data.
- ② Greater emphasis on community involvement: Many citizen science projects now place greater emphasis on involving and engaging local communities in the research process, rather than simply using them as data collectors.
- ③ Interdisciplinary approaches: There is an increasing number of interdisciplinary citizen science projects where researchers from multiple fields, such as environmental science, computer science, and social science, collaborate to address common research challenges.
- ④ Emphasis on data quality: There is a growing emphasis on the quality and accuracy of data collected in citizen science projects, ensuring that the data can be reliably used for research and decision-making.

● Limitations of Citizen Science

However, despite the many improvements that have been made, we must know that citizen science efforts have limitations.

- ① Data quality and consistency: Data collected by citizen scientists may vary in quality and consistency, requiring rigorous verification and standardization processes.
- ② Project design and management: Designing attractive and scientifically valuable citizen science projects requires expertise and careful planning.
- ③ Complexity of Data Analysis: Similar to open science, analyzing large amounts of data collected by citizens can be a major challenge for researchers.

● AI and Citizen Science

AI can significantly enhance citizen science in several ways.

- ① Automation of Routine Tasks: AI can handle tedious tasks such as image classification and data filtering, allowing scientists and volunteers to focus on more complex analysis and interpretation.
- ② Pattern Identification: AI algorithms analyze large datasets and identify hidden patterns and trends that humans might miss, leading to new discoveries.
- ③ Research guidance: AI can suggest areas for further investigation based on collected data, optimizing the research process.
- ④ Enhancing user experience: AI can personalize the citizen science experience by adjusting tasks to volunteers' skill levels and interests, increasing engagement and contribution.

● Examples of AI utilization

How is AI transforming citizen science?

- ① Disease detection: AI algorithms analyze medical images collected through citizen science projects and contribute to the early detection of diseases such as malaria and cancer.
- ② Wildlife monitoring: AI-equipped camera traps automatically identify animal species from captured images

and contribute to conservation activities.

③ Weather Pattern Classification: Citizen scientists can provide weather data using their smartphones. AI analyzes this data to improve weather prediction models.

There are probably quite a few citizen science projects around the world that have successfully embraced AI. This includes some of the most prominent activities, such as iNaturalist, Galaxy Zoo and eBird. The following five examples illustrate the multifaceted use of AI.

Flukebook

<https://www.flukebook.org/>

Mosquito Alert

<https://www.mosquitoalert.com/en/>

COMPAIR

<https://en.vmm.be/projects/compair>

miniSASS

<https://prospernet.ias.unu.edu/news/a-global-stream-assessment-scoring-system-minisass/>

Fold-it

<https://fold.it/>

● AI as a catalyst for collaboration between citizen science and open science

As we can see from the current examples, AI plays various roles in promoting citizen science.

① AI plays an important role in overcoming the challenges faced by open science and citizen science and paving the way for a more inclusive and collaborative scientific environment.

② Promoting Data Sharing: AI can build secure and efficient platforms for sharing research data, metadata, and related protocols. This enables researchers across disciplines and institutions to access and analyze relevant datasets necessary for their research.

③ Strengthening collaboration: AI-powered platforms can connect researchers across geographical and disciplinary boundaries based on their areas of expertise. This promotes collaboration, facilitates communication, and enables joint research projects.

④ Automated data analysis: AI can analyze large and complex datasets obtained from open science and citizen science projects to identify patterns, trends, and anomalies that might be overlooked by conventional methods. This not only accelerates discoveries but also allows researchers to focus on interpretation and constructing new hypotheses.

Several initiatives demonstrate the transformative power of AI in open science and citizen science.

① Large-scale citizen science for astronomical classification: This large-scale citizen science project uses AI to classify objects in astronomical images. AI first assists with preliminary classification and then improves accuracy over time by learning from the contributions of citizen scientists. This collaborative approach accelerates data analysis, enabling researchers to explore vast astronomical datasets and make new discoveries about the universe.

② Open-access disease research: During the recent large-scale infectious disease outbreak, researchers used

AI to analyze vast amounts of publicly available data on diseases, including genetic sequences, infection routes, and potential treatments. This enabled them to identify potential targets for new drugs and treatment strategies much more quickly than with traditional methods, saving lives.

③ Environmental monitoring through AI-powered data analysis: AI is used to analyze data collected from various open-source projects, such as satellite imagery and sensor data. This enables scientists to monitor environmental changes, such as deforestation rates, and improve models for predicting climate change, leading to the implementation of more effective environmental policies.

●The issue in a broader context: AI and social justice

AI has immeasurable potential to revolutionize various aspects of our lives, from healthcare to education to criminal justice. However, this potential comes with serious concerns. One such concern is the risk of perpetuating or amplifying existing social biases.

AI has the potential to be a powerful tool in combating discrimination and promoting equality. Here's how it works:

① Revealing bias: AI can analyze vast datasets to identify patterns of bias in areas such as hiring, loan approvals, and criminal justice. By exposing these hidden biases, AI can contribute to the development of more equitable policies and practices.

② Building fair systems: AI algorithms can be designed to prioritize fairness. For example, in hiring, AI can focus on skills and qualifications rather than biased factors such as sexuality and ages.

③ Promoting accessibility: AI can be used to develop tools that bridge the digital divide. Imagine AI-powered assistants translating languages or describing visual content for people with disabilities.

④ Empowering disadvantaged communities: AI can analyze data to identify and address the specific needs of marginalized communities. This includes targeted healthcare initiatives, education programs, and financial services.

However, we must be aware of the following challenges.

Biased datasets can lead to biased algorithms, creating a vicious cycle that worsens existing inequalities. Furthermore, the inherent complexity of AI systems, often referred to as “black boxes,” raises concerns about transparency and explainability. If we cannot understand how AI makes decisions, how can we identify and address potential biases? The unknown is not limited to the technology itself. Major control and access issues emerge. Who has the authority to develop and deploy AI? Will this technology worsen existing power imbalances and further marginalize those who are already on the margins?

⑤ Algorithmic bias: The fairness of AI systems is determined by the fairness of the data used for training. Biased data can lead to algorithmic bias, perpetuating existing inequalities.

⑥ Transparency and explainability: Many AI systems are complex “black boxes.” Lack of transparency may make it difficult to identify and address biases.

⑦ Access and control: Who controls the development and deployment of AI? Inequality in access to this technology may exacerbate existing power imbalances.

- Toward a Solution

A versatile approach is necessary for AI to become a force for good in the fight for social justice.

- ① Diverse teams: AI development teams must be diverse and inclusive, reflecting the communities that will be affected by the technology.
- ② Rigorous testing: AI systems must be rigorously tested for bias prior to implementation.
- ③ Regulation and oversight: Clear guidelines and regulations are necessary to ensure responsible AI development and use.
- ④ Public Education: It is important to raise public awareness of the potential pitfalls and possibilities of AI.

Future AI research and development should focus on building tools and frameworks to minimize bias, increase transparency, and strengthen ethical decision-making. Additionally, efforts must be made to bridge the digital divide and ensure that AI-driven social justice initiatives are accessible to everyone, regardless of socioeconomic status or background.

- Citizen science as a positive stimulus for AI research

Ongoing citizen science projects require a variety of skills, which seem to reflect the boundaries between human and AI capabilities. In other words, citizen science is rich in human common sense, ways of thinking, and complex tasks that are not yet incorporated into current AI methods. The fact that there is a vast amount of citizen science tasks that cannot yet be automated presents a valuable opportunity for the development of AI. Beyond the realm of citizen science, this could also help deepen our understanding of the interaction between humans and AI.