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What is Artificial Intelligence in Plant Breeding?

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Introduction

Artificial intelligence, or AI, is the term used to describe the creation and use of computer systems or other devices that are capable of doing activities that ordinarily call for human intelligence. AI includes a broad variety of tools and methods that provide computers the ability to mimic intelligent behaviour, gain knowledge from mistakes, and make independent judgements. To analyse data, identify patterns, and produce insights, AI systems frequently depend on algorithms, statistical models, and massive datasets. The study of artificial intelligence (AI) includes a number of subfields, such as machine learning, deep learning, robotics, and computer vision and natural language processing.

It's crucial to remember that while AI systems are very accurate at performing certain tasks, they frequently lack general intelligence comparable to that of humans. Current AI technologies are regarded as weak or limited AI since they are created to excel in particular fields but may not have wider cognitive capabilities. The subject of artificial intelligence (AI) is still developing quickly, with continual research and development attempting to expand the capabilities of machines.

What is AI plant breeding?

By incorporating additional data types and more advanced and improved prediction models, artificial intelligence (AI) may be utilised to enhance plant breeding. AI can improve

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the likelihood of finding really advantageous genotypes by concentrating on present breeding materials with the potential to reach optimum attributes. With the aid of computer science, breeders can quickly determine which plants grow the quickest in a specific climate, which genes support plant growth there and which plants, when crossed, produce the best gene combination for a specific location, choosing traits that increase yield and fend off the effects of a changing climate.

Artificial intelligence (AI) plant breeding is the practise of using AI methods and tools in the field of plant breeding. In order to increase the efficacy and efficiency of the breeding process, it entails employing AI algorithms and computational approaches to analyse sizable volumes of genetic, phenotypic, and environmental data pertaining to plants.

Various tasks and uses of AI in plant breeding include:

- **Analysis and prediction of data:** AI systems may examine genetic data to find patterns and correlations linked to desired qualities. Breeders may use this to forecast how various plant kinds will perform and choose the most promising candidates for additional breeding.
- **Genomic selection:** Before a plant is developed, genetic markers may be used by AI algorithms to determine its genetic worth. In order to make breeding efforts more effective and focused, breeders might use this to develop plants with desirable features early in the breeding process.
- **Trait prediction and optimisation:** Using AI approaches, some plant properties, such yield, disease resistance, drought tolerance, and nutrient content, may be predicted and optimised. AI models can help breeders choose plants with the required traits and hasten the breeding process by examining historical data and genetic markers.
- **Image-based phenotyping:** AI algorithms may examine photographs of plants taken by cameras or drones to assess a number of phenotypic features, including leaf area, plant height, blooming time, and disease signs. By automating and streamlining the phenotyping process, breeders are able to collect massive amounts of data more quickly and precisely.
- **Crop modelling and optimisation:** AI models used in conjunction with crop simulation software can simulate plant growth and forecast crop performance under various environmental circumstances. These models support plant breeders in maximising the

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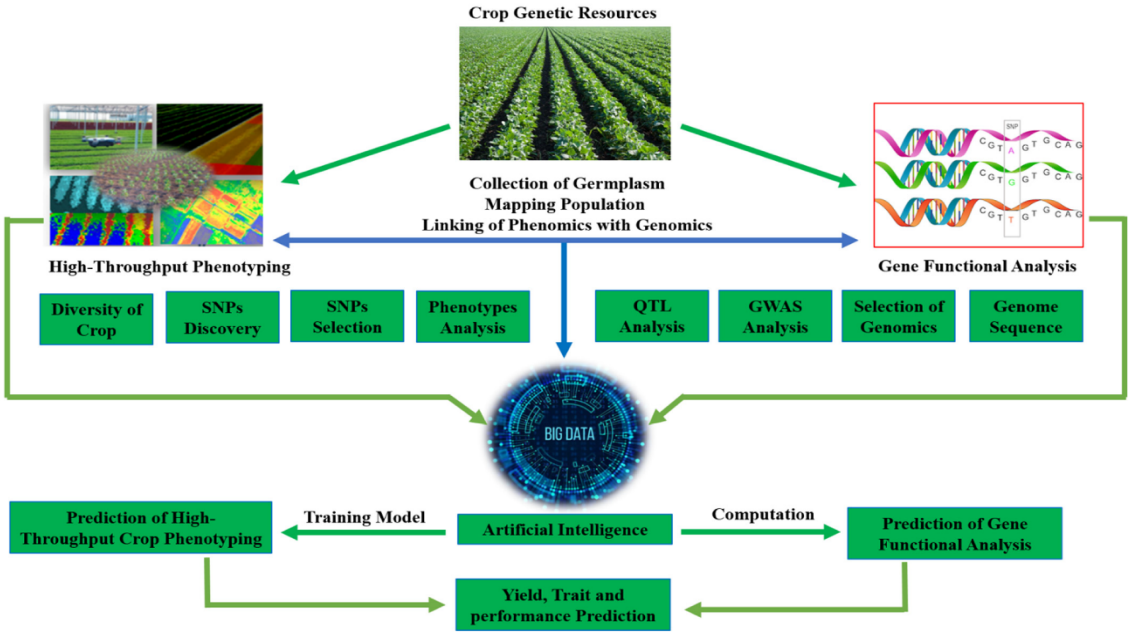
development of new plant types that are well-adapted to certain habitats by including parameters like temperature, rainfall, and soil quality.

- **Decision support systems:** Using a variety of data inputs, AI-powered decision support systems provide breeders insights and suggestions. These systems can detect prospective crossbreeding combinations, recommend the best breeding practises, and allocate resources efficiently.



Plant breeders may enhance the accuracy, speed, and efficiency of the breeding process by using AI techniques and technology. AI in plant breeding has the potential to help develop superior crop varieties that are better equipped to tackle the problems of food security, climate change, and sustainable agriculture.

There are several benefits to AI in plant breeding, and it might have a big impact on the plant breeding field.

AI is seen advantageous for the following reasons:

- ✓ **Effectiveness and speed:** AI systems can process enormous amounts of data fast and can carry out complicated analysis. This speeds up the breeding process and cuts down on the time needed to produce new plant varieties by enabling breeders to analyse enormous volumes of genomic and phenotypic data more effectively.
- ✓ **Accuracy and precision:** AI can find connections and patterns in data that may be difficult for humans to see. AI systems can predict plant features with high accuracy by

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examining genetic and phenotypic data, allowing breeders to make informed selection decisions.

- ✓ **Targeted breeding:** AI makes it easier to breed for certain qualities by locating plants that have those traits. By concentrating their efforts on plants that are more likely to display desirable traits, breeders can improve their chances of success and use less resources.
- ✓ **By examining extensive genomic data,** AI might unearth important genetic knowledge. Breeders can uncover genetic markers linked to desired features traits, which also helps them understand the genetic background of diverse phenotypes. Such knowledge can direct breeding plans and increase the effectiveness of trait enhancement and selection.
- ✓ **Task automation**: AI-based technologies can automate labour-intensive and repetitive processes involved in plant breeding. Examples include robotic systems and image-based phenotyping. This gives breeders more time to concentrate on important decisions and other time-consuming tasks.

Despite these advantages, it's critical to take into account any potential restrictions or difficulties related to AI in plant development. These include the requirement for high-quality and varied data, privacy and ownership issues, potential biases in data and algorithms, and the necessity of striking a balance between conventional breeding techniques and AI-driven approaches. While tackling these issues, carefully integrating and implementing AI in plant breeding can maximise its advantages and aid in the creation of better crop types.

How artificial intelligence is used in plant breeding

With the potential to completely alter how new crop types develop, artificial intelligence (AI) is quickly changing the area of plant breeding. Plant breeders can, identify and choose plants with desirable features more rapidly and effectively with the use of AI-powered tools. To find plants that have the potential to display particular features, such as resistance to pests or diseases or tolerance to drought or heat stress, AI may be used to analyse massive databases of genetic and phenotypic data. This can hasten breeding and shorten the time it takes to create novel kinds.

Implement breeding programmes that are more successful. AI may be employed to simulate the consequences of various breeding tactics on the results of a breeding programme.

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This can aid plant breeders in producing initiatives that are more likely to succeed in reaching their objectives. Development of novel breeding methods. New breeding methods like genomic selection and marker-assisted selection can be created using AI. These methods can aid in increasing selection accuracy and enable the selection of features that are challenging or impossible to evaluate directly.

By concentrating on present breeding materials that have the potential to produce ideal features, AI can raise the likelihood of identifying genotypes that are genuinely advantageous. AI can assist breeders in quickly determining which plants grow the quickest in a specific climate, which genes help plants thrive there, and which plants, when crossed, produce the best combination of genes for a given location.

Drawback of artificial intelligence in plant breeding

While AI has many benefits for plant development, there are certain drawbacks that must be taken into account. The following are some potential drawbacks of applying AI to plant breeding:

- **Dependence on data quality:** For training and analysis, AI algorithms largely depend on accurate and high-quality data. Poor-quality, incomplete, biassed, or biassed data can provide unreliable predictions and judgements when used to train AI models. The success of AI-based plant breeding depends on ensuring the accuracy and dependability of the data.
- **Lack of domain expertise:** To make sure that the proper factors and parameters are taken into account during analysis, AI systems need input and direction from topic specialists, such as plant breeders. The outcomes produced by AI models might not be properly evaluated or implemented without the necessary knowledge and understanding of the plant breeding domain.
- **Limited interpretability:** Deep learning models, a subset of AI algorithms, are well-known for their "black-box" character, which refers to their frequent interpretability limitations. While they are capable of making precise forecasts, it might be difficult to comprehend the underlying causes and motivations behind such projections. Breeders may find it challenging to completely understand and trust the judgements produced by AI algorithms due to this lack of interpretability.

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- **Over-dependence on computational approaches:** A decrease in hands-on, practical breeding practises may result from a heavy reliance on AI and computer technologies. Direct observation and involvement with plants in diverse situations are part of traditional breeding methods, which can yield insightful information. These practical abilities and experiential knowledge might be lost if AI is used too often.
- **Ethical and legal issues:** The use of AI in plant breeding creates legal and ethical issues that could argue for strict regulation. To ensure the safe and ethical use of AI in plant breeding, concerns about intellectual property rights, privacy issues around the sharing of genetic data, and any unexpected consequences of genetic modification must be addressed.
- **Accessibility and cost:**Adopting AI technologies and upholding the requisite computing infrastructure can be expensive, especially for smaller breeding programmes or organisations with constrained funding. Some breeders may find it financially difficult to implement these technologies due to the costs associated with gathering and analysing massive datasets, creating and training AI models, and staying up to date with the newest developments in AI.

It's crucial to remember that while there may be drawbacks, many of these difficulties may be overcome through careful application, cooperation between AI specialists and plant breeders, and ongoing development of AI methods tailored to plant breeding.

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