Big Data Analytics, ML & AI for Precision Agriculture & Smart Farming Systems

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Abstract

Big data and data scientific applications in the modern agriculture are rapidly evolving as the data technology advances and more computational power becomes available. The adoption of big data has enabled farmers and producers to optimize their agricultural activities sustainably with cutting-edge technologies, resulting in eco-friendly and efficient farming. Wireless sensor networks (WSN) and machine learning (ML) have had a direct impact on smart and precision agriculture, with deep learning (DL) techniques applied to data collected via sensor nodes. Additionally, internet of things (IoT), drones, and robotics are being incorporated into farming techniques. Digital data handling has amplified the information wave, and information and communication technology (ICT) have been used to deliver benefits to both farmers and consumers. This work highlights the technological implications and challenges that arise in data-driven agricultural practices as well as the research problems that need to be solved.

Keywords: Big data; Data analytics; Data science; Precision agriculture; Smart farming systems

State of the Art

- **ML:** crop production optimization, soil management, livestock management, harvest time prediction, determination of spraying areas of UAV
- **DL:** farm quality assessments, stress phenotyping, growth monitoring, yield estimation, variety recognition, plant disease prediction, crop yield prediction, crop price forecasting
- **Generative Adversarial Network (GAN):** classification of tomato crop leaf disease, disease identification in cucumber leaves, early detection of viral crop disease
- **IoT:** smart irrigation system
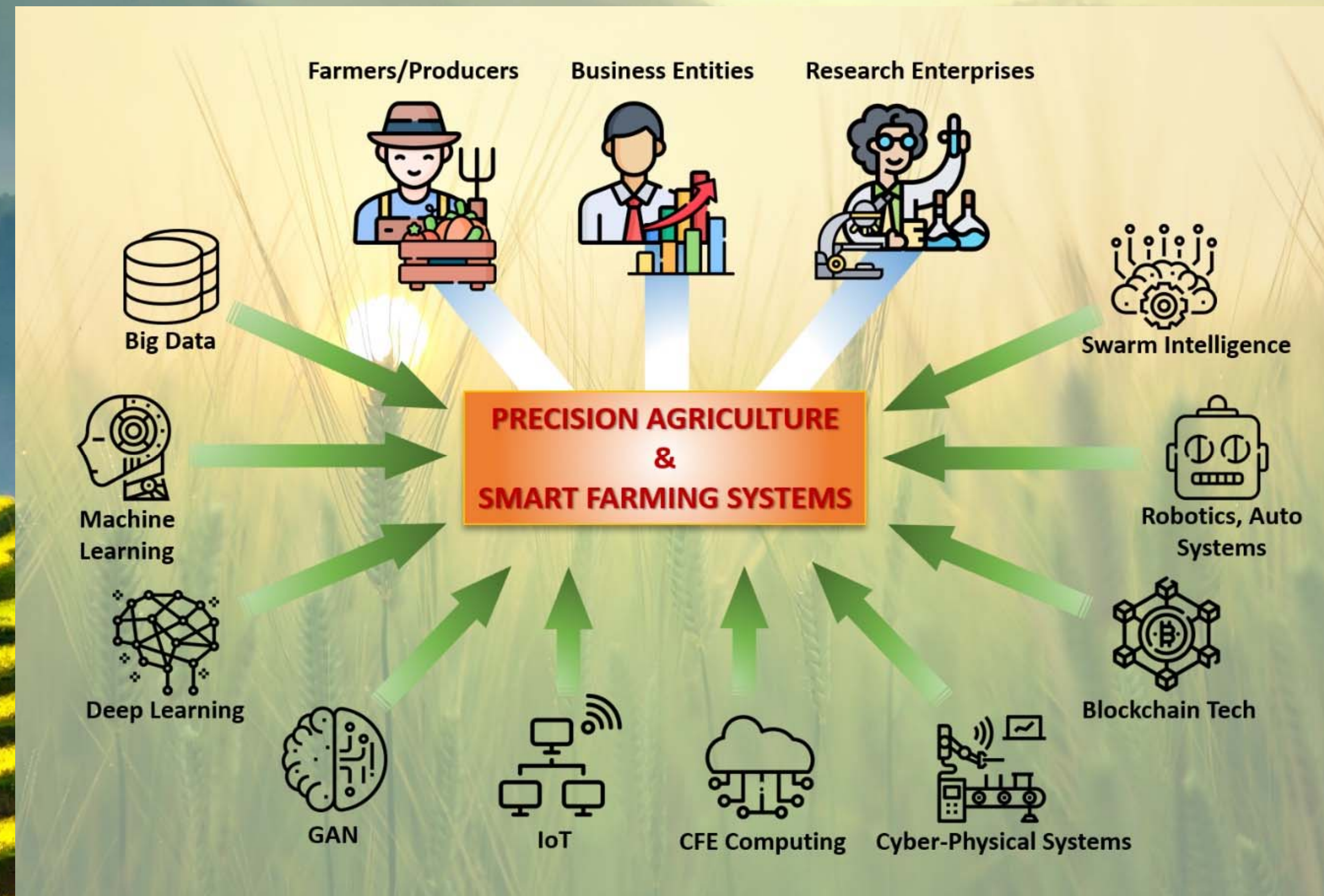
- **Cloud-Fog-Edge (CFE) Computing:** monitoring livestock activities on dairy farms
- **Cyber-Physical Systems (CPS):** smart pest control, fertilizer scheduling, water management for plant growth
- **Blockchain Tech:** agriBlockIoT traceability system for decentralized smart farming, livestock farming system
- **Robotics & Autonomous Systems:** plant factories, 3D food printing, UAV/UAS aerial spraying, biodiverse farming, autonomous farming; waste reduction in food supply chain; indoor organic farming and harvesting
- **Swarm Intelligence:** annual crop planning, agricultural products logistics, drones for smart farming, food operations, detection of plant leaf diseases

Challenges & Future

- ***Open Data & Open Access*** -- develop GODAN (Global Open Data for Agriculture and Nutrition); promote global collaborations and cooperations
- ***Data Security & Privacy*** -- keep agricultural operations safe, secure against cyberattacks and data breaches
- ***Adaptive & Novel Learning Models*** -- need adaptive and self-learning models to environmental changes; optimize models to improve accuracy + parsimony
- ***Hardware & Software Resources*** -- invest and develop infrastructures to support smart agriculture
- ***Communication & Training*** -- link researchers and agricultural experts to learn about challenges and find solutions; provide technical training and edu support
- ***Environmental Challenges*** -- make smart systems more resilient and agile against the climate changes

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