ⵜⴰⴳⵍⴷⵉⵜ ⵏ ⵍⵎⵖⵔⵉⴱ
ⵜⴰⵎⴰⵡⴰⵙⵜ ⵏ ⵜⵣⵔⴼⵜ ⴰⵏⴰⵎⵓⵔ
ⴰ ⵙⵓⵙⵙ ⴰⵎⴰⵏⵓⵔ ⴰ ⵙⵓⵙⵙⵉⵍⵙ

المملكة المغربية
وزارة التعليم العالي
و البحث العلمي و الإبتكار

جامعة ابن طفيل
ⵜⴰⵙⴷⴰⵡⵉⵜ ⵅⵓ ⴻⵙⵎⴰⵏ
Ibn Tofaïl University

AVIS DE SOUTENANCE D'UNE THESE DE DOCTORAT

Le Doyen de la Faculté des Sciences a le plaisir d'informer le public qu'une soutenance de thèse de Doctorat en

«Mathématiques, Informatique et Applications»

aura lieu le 11/07/2024 à la Faculté des Sciences, Kénitra

La Thèse sera présentée par Mme TAJI KHAOULA

Sous le thème :

Proposing and Implementing Secure and Intelligent Solutions for Soilless Agriculture Systems : Leveraging IoT, AI, and Cryptography for Sustainable Growth

Devant le jury composé de :

Nom et Prénom	Titre	Etablissement
AZOUAZI MOHAMMED	Président / Rapporteur	Faculté des Sciences BenMsik, Casablanca
BENLAHMAR EL HABIB	Rapporteur	Faculté des Sciences BenMsik, Casablanca
SADIK ABDELALIM	Rapporteur	Faculté des Sciences, Kénitra
MOUHIB OMAR	Examinateur	Faculté des Sciences, Kénitra
NOURI ANASS	Examinateur	Faculté des Sciences, Kénitra
GHANIMI FADOUA	Directeur de thèse	ENSC, Kénitra

UNIVERSITE IBN TOFAIL ★ PÔLE DES ETUDES DOCTORALES ★ KENITRA

رئاسة جامعة ابن طفيل، المركب الجامعي، ص.ب 242 - القنيطرة - 14000
Presidency Ibn Tofail University, University Campus, BP. 242 Kénitra 14000
(+212) 537 32 92 00 (+212) 79 45 21 30 05 UIT.ac.ma

Nom et Prénom : TAJI KHAOULA
Date de soutenance : 11/07/2024
Directeur de Thèse : GHANIMI FADOUA

Sujet de thèse :

Proposing and Implementing Secure and Intelligent Solutions for Soilless Agriculture Systems : Leveraging IoT, AI, and Cryptography for Sustainable Growth

Abstract:

The marriage of Internet of Things (IoT), security, and artificial intelligence (AI) technologies has sparked a revolution in smart agriculture, catalyzing innovation across various fronts. This thesis presents pioneering contributions in each of these domains, aimed at advancing agricultural practices and enhancing food security. In the domain of IoT, three novel contributions stand out. Firstly, an innovative IoT solution is proposed for the comprehensive control and monitoring of water quality and environmental parameters in aquaponics farming. Leveraging a scalable, secure, and interoperable architecture, this solution empowers farmers with real-time insights while ensuring cost-effectiveness and reliability. Secondly, an IoT-based irrigation management system is introduced, enabling remote monitoring and control of crucial parameters such as temperature, light, and soil moisture. Leveraging LoRa technology for long-distance communication and seamless integration with IoT cloud platforms, this system optimizes irrigation processes and reduces farmers' trips to the field. Furthermore, a proposed IoT-based hydroponics system is organized into four layers: Physical, Gateway, Middleware, and Application. Sensors and actuators are housed within the Physical Layer, while the Gateway Layer, driven by a NodeMCU microcontroller, manages data collection and relay control. The Middleware Layer ensures secure cloud connectivity through an MQTT broker (AdaFruitIo), and the Application Layer provides a mobile app for visualizing data. In the event of abnormal data values, the system initiates actions using relay-controlled actuators. This architecture offers a holistic solution for effectively monitoring and managing hydroponics operations. Security in smart agriculture is bolstered through a series of groundbreaking contributions. Beginning with an exhaustive exploration of cyber-attacks on smart farming systems, vulnerabilities are identified and addressed through innovative metamodels and security schemes. A new global meta-model for IoT and security in agriculture systems is presented, along with two robust schemes, CBHA and SCAK, offering resilience against diverse cyber threats. Moreover, a privacy-preserving homomorphic signcryption mechanism is introduced, leveraging Hyper Elliptic Curve (HECC) for enhanced security and efficiency in agricultural IoT deployments. In our AI contributions, we have proposed a multitude of research based on different algorithms. The first contribution involves utilizing CNN with hyperparameter techniques, including manual and automated techniques like Optuna, PSO, grid search, random search, and more, to choose the best CNN architecture. The second contribution focuses on Plant Disease Classification and Segmentation using a Hybrid Computer-Aided Model incorporating GAN and Transfer Learning. In the third contribution, we introduce a hybrid framework based on a hybrid preprocessing algorithm, an ensemble features engineering phase using texture features, and two types of deep feature extraction. CNN features are selected and fused with LBP features, and the ensemble feature vector is optimized using Binary Dragonfly Algorithm (BDA), Ant Colony Optimization Algorithm, and Moth Flame Optimization Algorithm (MFO). This comprehensive analysis addresses plant diseases affecting fruits and vegetables, acknowledging limitations and paving TAJI Khaoula 2 the way for future research. The proposed technique achieves a remarkable accuracy of 99.8%, surpassing current state-of-the-art methods, contributing to food security and sustainability by enabling early identification and classification of plant diseases.In our proposed LWYoloV8-seg model, trained on a custom dataset, we achieved outstanding performance with an impressive 99% accuracy, 0.9556 mAP, and notable efficiency metrics. These include a small model size of 9.23 MB and a rapid inference time of 2.5 ms. Furthermore, beyond disease detection, our model seamlessly integrates with a recommendation system. By leveraging detected diseases, farmers receive targeted treatment recommendations, empowering them with actionable insights for effective crop management. Through rigorous experimentation and evaluation, these contributions not only advance the state of the art but also offer practical solutions for sustainable and resilient agricultural practices. By harnessing the synergies of IoT, security, and AI, this research aims to transform smart agriculture, empowering farmers with actionable insights and fostering global food security and sustainability.