**Portfolio: AI Systems**

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Semester 5: Minor

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# Version Control

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| **Version** | **Date** | **Change** |
| V0.1 | 15.09.2025 | The basic outline of the first draft version |
| V0.2 | 26.9.2025 | First Revision: 1a and 1b |
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# Abbreviations

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# Part 1: Learning Goals

## 1a: Personal Learning Plan

### Student Profile

I have an informatics education with a focus on software engineering, and most of my prior work revolved around software development and programming, with little work on artificial intelligence. Form someone who came into this minor with little to no knowledge. My interest in AI is growing, especially its application in sustainability and green technology.

In this independent study, I want to contribute by designing and building an intelligent system for water quality in hydroponic farming. Specifically, I want to develop a system that employs IoT sensors and AI technology to monitor and analyze EC, pH, temperature, and dissolved oxygen to fine-tune hydroponic systems in real-time to maximize water and nutrient use efficiencies. The use of predictive analytics in this system will assist farmers in reducing waste and increasing sustainable agricultural practices by improving crop yields.

Upon completion of this Minor Program, I intend to combine my software engineering background while learning about how to implement an embedded AI-enabled IoT system solution to address sustainability challenges, thus providing the sector with my newly acquired practical knowledge.

### Self-reflection

Previously in software development and programming projects we are challenged to grow in conducting structured requirements analyses, designing software architectures, and, in an organized manner, overseeing the entire software development cycle. We are told to find what we want to learn and develop or refine through project-based learning. So far, while I have good implementation skills, I recognize I need to improve in:

* **Software knowledge: learn Python, key AI tools (Open frameworks and libraries), learning through the workflow process of developing an AI predictive system.**
* **Requirements analysis:** capturing user needs, acceptance criteria, evaluate risks
* **Architecture design**: Understanding Typical Architecture for complex AI/IoT systems
* **Evaluation & Communication**: Clarify decision, and justify decision choices
* **Management skills**: Organization, Kanban Board Planning, Repo

This AI systems minor provides me the opportunity to expand beyond coding into **end-to-end system development,** preparing me to contribute to AI-focused industries.

### Personal Learning Objectives

**1. Technical Knowledge & Skills**

* **AI & IoT Integration**: Develop the ability to design, build, and deploy AI-enabled IoT systems for real-time monitoring and optimization in water quality in hydroponic farming.
* **Predictive Analytics**: Learn to apply data-driven models for forecasting and decision-making to improve sustainability outcomes.
* **System Optimization**: Gain expertise in using IoT sensor data (EC, pH, temperature, oxygen) to fine-tune hydroponic systems.

**2. Software Engineering & Architecture**

* **Requirements Analysis**: Improve skills in capturing user needs, acceptance criteria, and risk analysis for complex projects.
* **Software & System Architecture**: Learn to design robust architectures for AI/IoT solutions that ensure scalability and reliability.
* **Development Lifecycle**: Strengthen capabilities in planning, continuous integration, and release cycles (CI/CD).

**3. Evaluation & Advising**

* **Technology Assessment**: Learn to critically evaluate and justify technology choices for AI and IoT applications.
* **Sustainability Impact Analysis**: Understand how to evaluate the ecological and efficiency outcomes of intelligent systems in agriculture.

**4. Professional & Management Skills**

* **Project Management**: Develop organizational and planning skills for overseeing complete system development cycles.

**5. Personal & Career Development**

* **Bridging Backgrounds**: Combine software engineering expertise with applied AI/IoT for sustainability challenges.

## 1b: Theoretical Learning Plan

### Context

Agriculture is one of the most resource-intensive industries, consuming vast amounts of **water, nutrients, and energy.** Hydroponics has emerged as a soil-free sustainable alternative method of cultivation. However, hydroponic systems require **close monitoring and isn’t quite affordable. Water quality plays a major role if you think about pH, nutrient levels, temperature, oxygen and how these impact the plant health and crop yield.**

Artificial intelligence can play an important role in enhancing hydroponic farming by:

* It enables predictive analytics, catching issues in nutrient or water levels before they become big problems.
* It supports real-time, data-driven decision-making, so growers aren’t flying blind.
* It makes resource management more efficient, which both reduces waste and aligns with broader sustainability goals.

**State of the art**:

* **IoT in agriculture**: A wide range of sensors are available to measure water parameters, but many existing solutions rely on human interpretation.
* **AI for predictive analytics**: Machine learning models can flag anomalies, predict trends, and optimize control strategies, yet integration into small-scale hydroponic systems remains limited.
* **Knowledge gap**: Integrated systems that combine IoT sensors and AI driven analytics for hydroponics seem cost ineffective for small-scale growers.

**Main Research Question**:  
*How can AI be applied to optimize hydroponic farming by combining IoT-based monitoring of water parameters with predictive analytics for sustainable resource management?*

**Sub Questions:**

1. **Which water parameters (e.g., EC, pH, temperature, dissolved oxygen) are most critical in hydroponic farming, and how do fluctuations in them affect crop growth and resource efficiency?**
2. **What IoT sensors and data pipelines can be used to reliably measure and transmit these parameters in real-time within a hydroponic setup?**
3. **How should sensor data be preprocessed (e.g., cleaning, normalization, handling anomalies) to make it suitable for predictive modeling?**
4. **Which predictive analytics and AI techniques (e.g., regression, time series forecasting, anomaly detection) are most effective for forecasting water quality and detecting irregularities?**
5. **How can IoT monitoring and AI models be integrated into a system architecture that supports real-time decision-making and control in hydroponics?**
6. **What forms of visualization, feedback, or decision support (dashboards, alerts, recommendations) can make the system usable and valuable for farmers?**
7. **To what extent can AI-driven optimization reduce water and nutrient waste, and what is the ecological and financial impact compared to traditional/manual approaches?**
8. **What risks, limitations, and future opportunities arise when applying AI and IoT to hydroponic farming for sustainable resource management?**

### Theoretical Learning Objectives

Based on Bloom’s taxonomy, I aim to reach:

* **Understand**: Review and synthesize current research on AI applications in agriculture, IoT integration, and sustainable practices.
* **Apply**: Develop and Implement AI-driven solutions for predictive analytics in hydroponic water quality monitoring.
* **Analyze**: Evaluate the financial, ecological, and technical impact of integrating AI into hydroponic farming.
* **Create**: Design and prototype an AI-enabled IoT system that supports sustainable hydroponic practices.

**Inspirational Sources**:

### Academic articles on AI in precision agriculture and hydroponics.

### Documentation and case studies on IoT frameworks (Raspberry Pi, Arduino, cloud-based data platforms).

### Practical guides for AI tools such as scikit-learn and TensorFlow Lite.

### Literature on sustainability and resource optimization in agriculture.

### Learning Strategy

**Planned Activities**:

To achieve these objectives, the following activities are planned:

1. **Literature research**: Review scientific papers and industry reports on AI and IoT in hydroponics.
2. **Requirements analysis**: Define user needs, acceptance criteria, and possible risks for the system.
3. **Prototype development**:
   * Build a sensor system for real-time water quality monitoring.
   * Develop a predictive analytics model to analyze and optimize parameters.
   * Integrate data collection, storage, and visualization pipelines.
4. **Validation**: Test the system for reliability, accuracy, and sustainability impact.
5. **Evaluation**: Compare ecological, technical, and financial outcomes against conventional methods.
6. **Reporting**: Document the process, results, and reflect on the learning goals.

**Time Schedule:**

### ****Phase 1 – Orientation & Research (Weeks 1–3: Sept 30 – Oct 20)****

* **Week 1 (Sept 30 – Oct 6):**
  + Kick-off, review project requirements.
  + Conduct initial literature research on AI in hydroponics and IoT applications.
  + Identify potential sensor types (EC, pH, temperature, oxygen).
* **Week 2 (Oct 7 – Oct 13):**
  + Deep dive into predictive analytics techniques (time series, anomaly detection, regression models).
  + Explore open-source frameworks (TensorFlow Lite, scikit-learn, cloud IoT services).
* **Week 3 (Oct 14 – Oct 20):**
  + Summarize state-of-the-art findings.
  + Draft acceptance criteria and risk analysis.
  + Document initial project scope and success factors.

### ****Phase 2 – Requirements & Architecture (Weeks 4–5: Oct 21 – Nov 3)****

* **Week 4 (Oct 21 – Oct 27):**
  + Define functional requirements (data collection, analytics, visualization).
  + Define non-functional requirements (scalability, reliability, sustainability).
  + Prepare use cases and system scenarios.
* **Week 5 (Oct 28 – Nov 3):**
  + Create system architecture (IoT sensors → data pipeline → AI model).
  + Select technology stack (hardware, frameworks, cloud/local storage).
  + Finalize architecture documentation.

### ****Phase 3 – Data Collection & Preparation (Weeks 6–7: Nov 4 – Nov 17)****

* **Week 6 (Nov 4 – Nov 10):**
  + Procure or simulate sensor data (EC, pH, temp, oxygen).
  + Begin logging data streams from sensors (if physical setup is available).
  + Collect historical datasets (from public sources if needed).
* **Week 7 (Nov 11 – Nov 17):**
  + Preprocess collected data (cleaning, normalization).
  + Explore dataset structure (trends, correlations, anomalies).
  + Split data into training/testing sets.

### ****Phase 4 – AI Model Development (Weeks 8–9: Nov 18 – Dec 1)****

* **Week 8 (Nov 18 – Nov 24):**
  + Design initial predictive model (e.g., regression for pH/EC prediction).
  + Experiment with anomaly detection for detecting irregular water quality.
  + Test model performance with sample datasets.
* **Week 9 (Nov 25 – Dec 1):**
  + Optimize model parameters (feature engineering, hyperparameter tuning).
  + Evaluate results with metrics (accuracy, RMSE, reall, precision).
  + Document findings and prepare integration plan.

### ****Phase 5 – Prototype Development (Weeks 10–11: Dec 2 – Dec 15)****

* **Week 10 (Dec 2 – Dec 8):**
  + Develop IoT pipeline: sensors → microcontroller → cloud/database.
  + Implement data ingestion and storage (e.g., MQTT, Firebase, or REST API).
* **Week 11 (Dec 9 – Dec 15):**
  + Integrate AI model with the pipeline (real-time predictions).
  + Build dashboard or interface to visualize water quality parameters and recommendations.
  + Conduct integration testing.

### ****Phase 6 – Testing & Validation (Weeks 12–13: Dec 16 – Dec 27)****

* **Week 12 (Dec 16 – Dec 22):**
  + Perform functional testing of sensors and AI predictions.
  + Validate system against defined acceptance criteria.
  + Document technical risks and limitations.
* **Week 13 (Dec 23 – Dec 27):**
  + Evaluate ecological and financial impact (e.g., potential savings in water/nutrients).
  + Compare system performance against baseline/manual monitoring methods.
  + Gather feedback (if user test participants available).

### ****Phase 7 – Finalization & Reporting (Week 14: Dec 28 – Jan 2)****

* **Week 14 (Dec 28 – Jan 2):**
  + Finalize documentation of system design, implementation, and results.
  + Write full report including reflection on personal learning goals.
  + Prepare presentation/demo.
  + Submit project before January 2.

# Part 2: Learning Activities

## 2a: Personal learning Activities

### Feedback

*During the specialization the student will at least twice set up a 360°-feedback in which she asks feedback on the formulated personal learning objectives (part 1a of the portfolio). In order to get a complete vision on the student’s professional functioning the student asks feedback from different angles (involved parties with different roles within the study process of the student – e.g. experts from the field, experts from Fontys, the coach and peer students)*

For this individual study I will plan two moments to gather feedback during the semester to gain insight into my personal and professional progress so that I can have an objective view of if I am meeting my expected goals. By actively gathering feedback I can accurately gage my progress and if I have maintained the path that I have set for myself.

**Planning:**

**First 360°-feedback Round (Week 5- After Requirements and Architecture)**

I shall ask for feedback from my independent study coach, two of my peers, and an expert in AI who can provide mentor like insight. The expected focus is to get early feedback on my research approach, project planning, and execution of the analysis phase.

**Planned Participants:**

* Coach: To assess progress, critique artifacts, and gage progress toward my learning objectives.
* Expert: To gain Insight and advising on system architecture, model design, and feasibility
* Peer: To give an outside perspective on my artifacts and whether communication is clear.

**Second 360°-feedback Round (Week 13- Testing and Validation)**

I shall ask for feedback from my independent study coach, and the same expert in AI from reflection one. This way I can reflect on the progress between both meetings. The expected focus is reflecting on the previous feedback and how it has guided my project towards my learning outcomes. How communication of results, project management, and my professional growth has changed.

**Planned Participants:**

* Coach
* Experts

This second round is to evaluate how well I have developed towards my goals and provide an objective view on how to my own future development.

### Self-reflection on feedback

*The student combines the 360°-feedback constantly with a written self-reflection, in which the student describes his/her own vision concerning the development in the formulated personal learning objectives. The student reflects on the performed learning activities and also reflects on her (constructive) actions on the received feedback. The student evaluates whether the development strategy as formulated in part 1a of the portfolio has been effective in fulfilling the personal learning objectives and either suggest a new strategy that might add in completing the personal learning objectives, or formulate new personal learning goals.*

My structured plan for self-reflection is:

* Summarize key points from each participant.
* Use the summarized key points to compare their observations with my personal learning objectives in Part 1a.
* Reflect on their observation, define possible actions to take to improve and strengthen possible weak areas or skills.
* Based on the reflection, I will adjust my development strategy or apply changes to my artifacts or documents. Whether this requires me to learn further in areas that I may be weak in to develop stronger skills and produce better results.

Through this process, I aim to meet my goals, further develop my management skills, and monitor my own self-growth so that I may meet my objectives and stay on track within the AI Systems minor.

The feedback that I received from my coach for Part1 of this document seemed quite positive, so I feel my initial development strategy is realistic and well-structured. The feedback pointed out some areas that may be weak and need improvement.

There were good suggestions such as seeking advice from an expert and looking into anomalies that can occur because this could largely affect my project. The advice that the occurrence of anomalies can change how the algorithm works or what sensors might be needed is a stress point for my preliminary research. Another thing I hadn’t considered was whether I would extend the system architecture to allow user input or manual adjustments. This might be very helpful for the user because then they can adjust the water based on what they are growing. With this insight, I will be able to make a better-informed decision on which algorithm and sensors will best suit this study.

## 2b: Theoretical Learning Activities

### Learning Activity Reports

*In this part of the portfolio the student includes the L.A.R. of all learning activities as formulated in part 1b of the portfolio. When the student, because of progressive insights, has chosen not to perform, alter or add certain learning activities, the student will reflect on the made choices. In the L.A.R. the student will pay attention to following:*

* *Preparations: The student prepares for each learning activity by activating current knowledge and the (originally stated) theoretical learning objectives, related to the current learning activity. The students revives the conclusions that have been drawn from earlier performed learning activities and relates them to the current learning activity. Furthermore, the student reflects on the type of source that will be used in the current learning activity and weighs this in her expectations from the learning activity.*
* *Content of the learning activity: The student briefly summarizes the content of the learning activity. Herein the students identifies information that is crucial for answering the theoretical learning objectives and places the content in the larger context of the earlier learned theory.*
* *Conclusions: The student draws conclusions from the learning activity. The student evaluates to which level the current learning activity added in answering the originally stated theoretical learning objectives and either suggests new learning objectives that might add in answering the theoretical learning objectives, or formulates new theoretical learning goals.*

In this part of the portfolio, I will include the Learning Activity Reports for each theoretical learning activity formed in Part 1b. Since this document is the starting phase of my individual study, the L.A.R.s will be developed throughout the entire semester as each activity is completed. Here is my structured outline for the L.A.R.s in a template form. Each L.A.R.s will cover three areas: Preparation, Content, Conclusion.

## L.A.R # Template – Phase Title

**1.Preparations:**

Objective:

Current knowledge:

Preparatory Actions:

Expectations:

**2. Content of the Learning Activity**

Summary of the Activity:

Key Information Identified:

Connection to Theory:

**3. Conclusion and Reflection**

Conclusions:

Added Value to Learning Objectives:

Progressive Insights/Adjustments:

Next Steps/Follow-up Activities: