

DSP INTEGRATION FOR SMART COMPOST MONITORING

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Introduction:

The Eco Blend compost preparer, integrating Digital Signal Processing (DSP) and Machine Learning (ML), represents a technological leap in waste management and organic farming. Traditional composting, often hampered by static parameters and sporadic human intervention, suffers from inefficiencies and suboptimal outcomes. The Eco Blend addresses these issues by providing real-time analysis and dynamic adjustment of crucial variables like temperature and moisture content. DSP algorithms filter noise from sensor data, extracting meaningful insights to optimize the composting process. This system's adaptability to varying waste compositions ensures precision control, enhancing resource utilization and sustainability. Predictive analytics offer proactive estimations of compost maturity, while fault detection mechanisms enable timely interventions, ensuring a robust composting workflow. Beyond automation, the Eco Blend envisions a comprehensive transformation towards intelligent, data-driven composting. By integrating IoT for smart waste monitoring and real-time soil fertility measurements, it enhances efficiency and sustainability across the agricultural value chain. This advanced composting system not only minimizes the ecological footprint but also aligns with stringent environmental regulations, promoting soil health and agricultural productivity amidst climate uncertainties.

Objectives:

1. Develop a smart composting system by integrating DSP and IoT to revolutionize control and monitoring.
2. Optimize composting conditions using cloud-based sensor data and DSP algorithms for precise microbial activity.

3. Improve efficiency and compost quality via real-time data-driven insights for optimized production.
4. Implement Machine Learning based compost maturity prediction to determine optimal usage timing.
5. Provide plant recommendations based on final compost composition analysis for enhanced utilization.

Methodology:

In addressing the limitations of traditional composting methods, the proposed DSP Integration for Smart Composting Monitoring system employs a systematic methodology to enhance composting efficiency and sustainability. The system initiates with a clear definition of objectives, aiming to overcome the limitations of static composting parameters. Advanced sensors, such as pH, temperature, ammonia, oxygen, CO₂, and humidity sensors are strategically positioned within a ventilated cylindrical container, supported by a sturdy stand. These sensors provide real-time data on crucial composting indicators, ensuring an optimal environment for microbial activity. The cylindrical container serves as a controlled environment for composting, emphasizing the importance of proper ventilation to regulate temperature and ensure adequate oxygen levels for aerobic decomposition. The sturdy stand not only provides stability but also accommodates a motor-driven mixing system featuring blades designed for efficient compost turning. At the core of the system is the Arduino microcontroller, serving as a central processing unit to receive sensor inputs and facilitate communication among hardware components. The backbone of the real-time monitoring system. In the above figure 3.1 the Arduino acts as a central hub, orchestrating the flow of data between the various sensors and facilitating seamless communication with the hardware components. Using ESP8266 wi-fi module the obtained sensor data are pushed to ThinkSpeak for real time access.

The efficiency of this communication is essential for the timely processing of data, a task that falls under the responsibility of the Digital Signal Processing (DSP) algorithms. The DSP algorithms, executed through MATLAB, showcase the project's sophistication. MATLAB processes the raw sensor data, applying machine learning algorithms to predict compost maturity. The threshold fall in parameters a dynamic approach to parameter adjustments. The real-time analysis provided by DSP, IOT and ML allows for the continuous optimization of composting conditions, ensuring analysis.

The output from ML algorithms and sensor data from ThinkSpeak the suitable plant to use the compost in the current state is predicted, by analysing the final compost composition using advanced data analysis, the system will recommend plants that thrive best with those specific characteristics. This personalized

plant recommendation maximizes the effectiveness of the compost, ensuring optimal growth for your chosen species.

The traditional compost preparation takes around 150 days. so, this system takes approximately 45 days less in process, this increases the efficiency upto 30%.

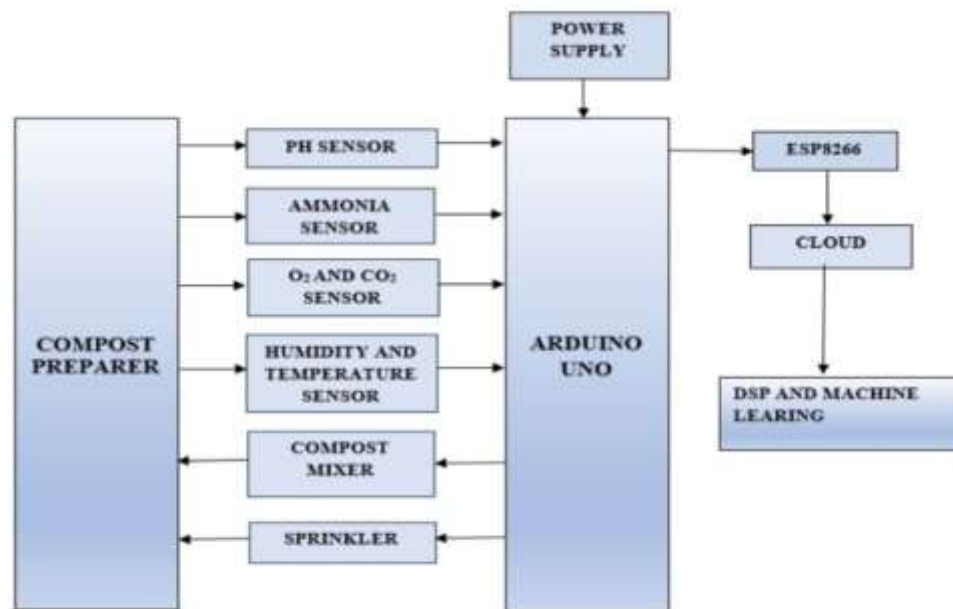


Figure 1: Block diagram of DSP integration for smart compost monitoring

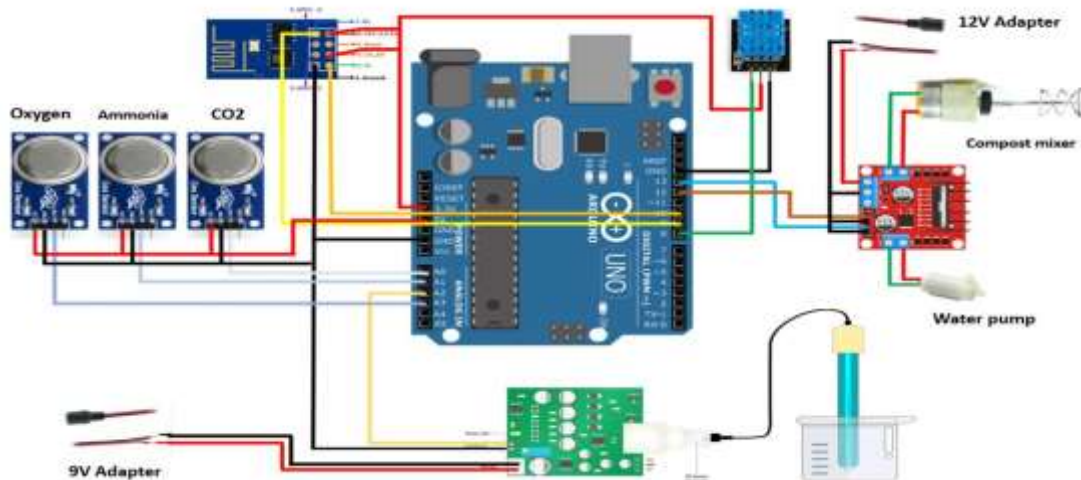


Figure 2: Circuit diagram of DSP integration for smart compost monitoring

Conclusion:

Integrating IoT, Machine Learning (ML), and Digital Signal Processing (DSP) can revolutionize smart compost monitoring by optimizing efficiency and effectiveness. IoT sensors can continuously collect data on temperature, humidity, and pH levels from compost bins. This data is transmitted to a central system where DSP techniques filter and preprocess it, removing noise and ensuring accuracy. ML algorithms then analyze the processed data to predict optimal conditions for composting. This integration enhances compost quality, reduces manual monitoring, and supports sustainable waste management practices. The system can also learn from historical data, improving its predictive capabilities over time. Overall, this smart monitoring solution ensures a more efficient composting process, leading to better resource utilization and environmental benefits.

Scope for future work:

Future composting methods aim for efficiency and sustainability with renewable energy. Smart systems ensure precise control, enhancing waste management. Blockchain enables transparent tracking, fostering trust. Innovations like vermicomposting offer alternative waste management, addressing environmental challenges. Additionally, nutrition detection enhances compost quality, while tracking carbon footprints boosts accountability and mitigates climate impact.