IntelliMod: Intelligent Model Based Agent For Composting

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Abstract

Composting involves various aerobic micro-organisms decomposing raw organic materials to obtain energy and materials that they need for their growth and reproduction. The by-products of the decomposition, the microorganisms, and parts of the raw material make up the end product that is called compost. The organisms that are responsible for composting require certain nutritional and environmental conditions to survive. They require specific quantities of macro and micro-nutrients, oxygen, and water. They experience best growth rates only within a certain range of temperature and humidity.
All these specifications make the process of composting require constant observation and attention. This work focuses on designing an agent such that human intervention can be minimised and contaminants like fungus can be prevented in the raw materials like alfalfa, hay, straw etc.

1. Introduction

The study aims to solve the problem of continuous supervision of the delicate process of composting in the Indian context.
Experts say that just by segregating, recycling and composting, a family of four can reduce their waste from 1000 Kg to less than 100 kg in a year [1]. The organic content of Municipal Solid Waste (MSW) tends to decompose leading to various smell and odour problems. It also leads to pollution of the environment. Composting process is quite commonly used and results in the production of a stable product - compost which depending upon its quality can be used as a low-grade manure and soil conditioner. The process results in the conservation of natural resources and is an important processing method, especially in agricultural and horticultural areas.[2]

Without proper aeration and water, composting can become an anaerobic process that produces gases, which then result in a rotten smell.
The goal is to have minimum human intervention while maintaining the minimum cost of implementation.
An *agent* in Artificial Intelligence is anything that can a) perceive its environment through ***sensors*** and b) act upon that environment through ***actuators.***[3] This study attempts to develop an AI agent which helps control the **humidity** and **temperature** levels in the compost raw materials (hay, straw, etc.) to prevent fungus and other microbial contaminants in it.
The agent proposed, in the work, is a combination of a *model-based reflexive agent* and *learning-based agent - IntelliMod.*

A *model-based reflexive agent* is used in a partially observable environment with the help of an internal state which is manipulated by each percept. In each iteration information about how the world evolves independently from the agent, and, how the agent actions affect the world is passed.
A *learning-based agent* is capable of learning based on its own experience and hence it will be able to adapt to its surroundings better than a hard-coded agent system. [3]

Background and important details about composting is provided in Section 2 under the name Background. Related Work and Literature is studied in Section 3, in Section 4 the proposed agent is discussed in detail under the Results heading. In Section 5, the Implementation of the model is depicted and at the end, the Conclusion is discussed in Section 6 and Section 7 lists the References for the study.

2. Background

Composting and its benefits have been known since the tenth century. Greeks and Romans have known about compost since in tenth- and twelfth-century. It is also mentioned in Arab writings, in medieval Church texts, and Renaissance literature.[4] Since then, the definition of compost has evolved with science. And today, compost, in general, is high quality, nutrient-rich, inactive manure that detracts insects and pests. The process of composting needs expertise in the field and proper supervision which makes it costly and prone to corruption. Process corruption can further result in toxicity in the agriculture materials which can be harmful for the consumers and the surrounding habitat.
The composting procedure consists of two major phases, the **decomposition** and the **maturation** phase. The decomposition phase involves intense microbial activity, started by the rapid decomposition of the material. This phase further has two sub-phases depending on the

material's temperature. In the first subphase - the *mesophilic phase,* decomposition has just begun, and the temperature rises, up to 60 ◦C. In the second subphase - the *thermophilic phase*, decomposition is in full extension and the temperature rises to 65–70 ◦C. During these two subphases, the material's moisture content should be kept between 50% and 60%. The moisture level is below 50% in the second phase and the process slows down or stabilizes.[5]
If the moisture increases above 60%, it makes the composting process anaerobic and results in contamination of the process. The duration of the first phase is from fifteen to thirty days and for the second phase, from thirty to sixty days. In Figure 1, Temperature relation with the composting phase is shown.

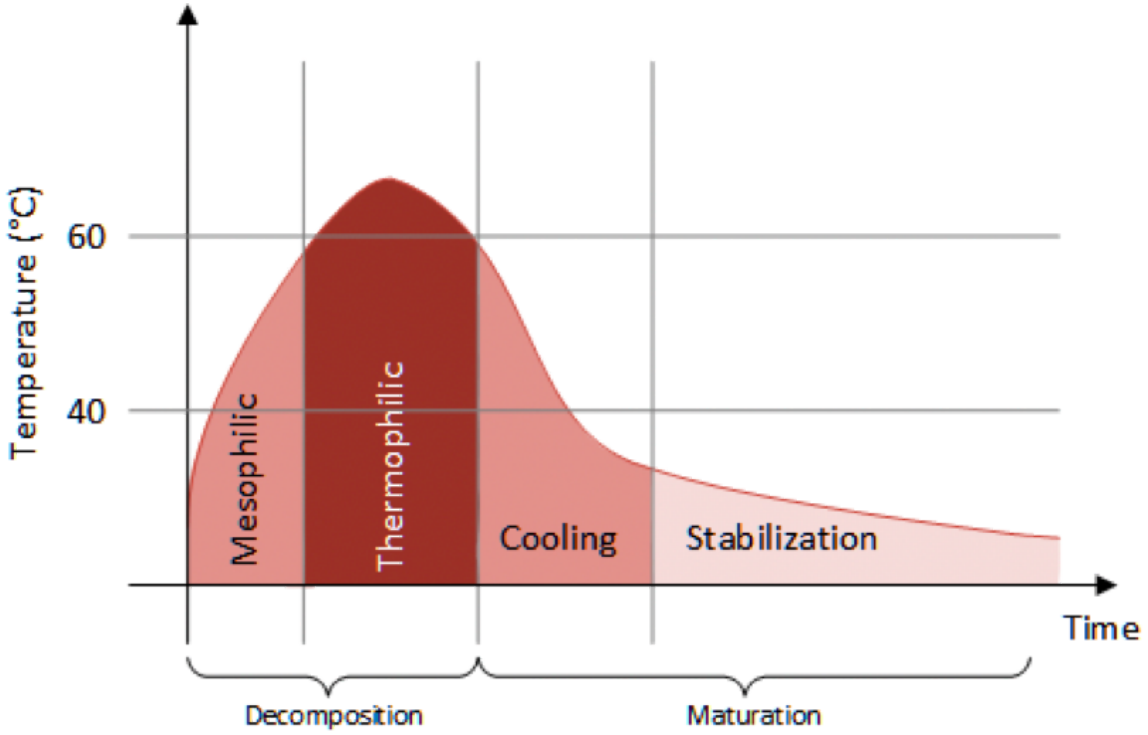

Fig 1. Relation of Temperature with the Composting process [5]

3. Related Work

In Reference[6], Jordão et al. presented a Low-cost automation service for temperature monitoring in compost. It was published in 2017. In Reference[7], Rahane et al. introduced a

composting infrastructure that periodically performs specific tasks (stirring, ventilating, etc.), and also performs dynamically invoked actions, according to the compost material's temperature. In 2018 Yannis et al. presented an IoT based real-time analysis system for composting service which is the latest cloud computing-based [5]. Earlier to these few studies have been done on monitoring other factors for composting like Laura Capelli studied Oxygen and Carbon dioxide levels (electronic nose) in their 2014 paper [8], gas emission. In this study, we attempt to design a new kind of agent which focuses on controlling the temperature and humidity in raw materials of compost in an efficient manner.

4. Discussion of the Proposal

Although the prevention of fungi and other microbial contaminants in the raw materials of compost depends on many factors like temperature, moisture, C:N Ratio, Oxygen and Carbon dioxide levels, segregation of content etc. , the scope of this report discusses mainly two factors: temperature and moisture content in the soil particles.

4.1 The Agent Design

As discussed previously, the agent - **IntelliMod**, is a combination of a model-based reflexive agent and learning-based agent. It is a model-based reflexive agent which has a *critic*, l*earning element* and a *performance element* in it. The learning element is required for the cases of climate changes like rainfall (soil erosion). The agent must be able to learn from the environment changes and also act quickly based on it. Real-time analysis is also very helpful in the prevention of contamination in the composting process.
Figure 2 illustrates the proposed IntelliMod Agent System. The Environment consists of the raw materials like hay, straw etc. , the soil, air and other surrounding particles.

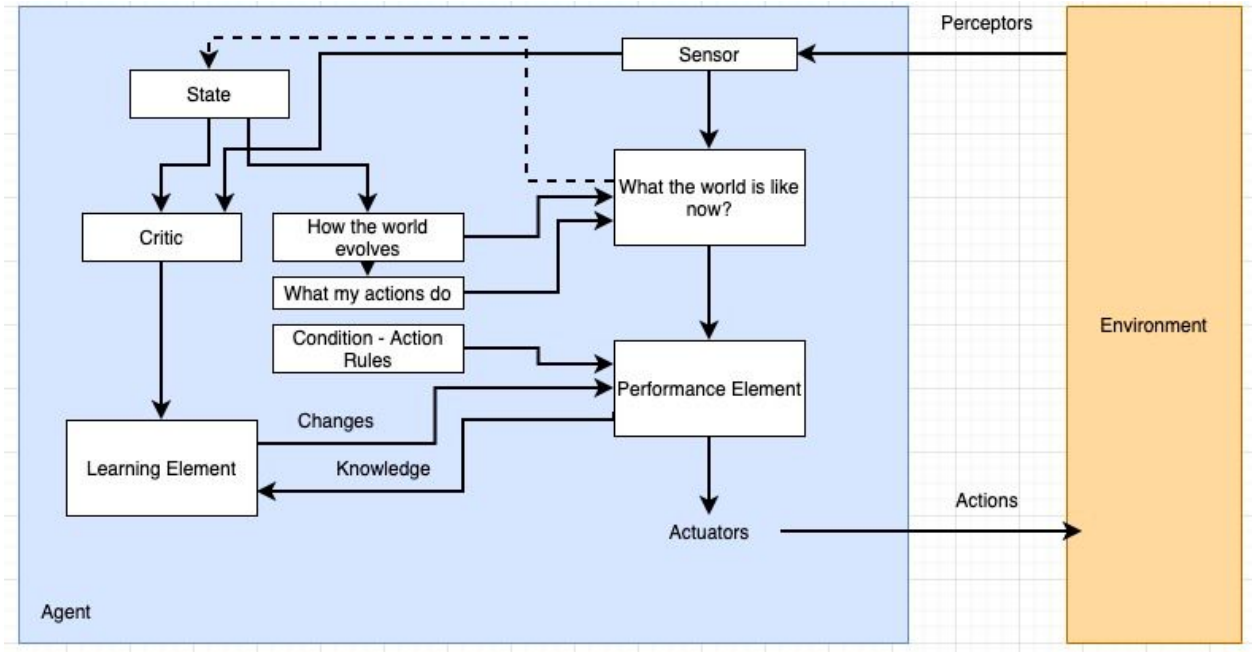

Fig 2. IntelliMod Agent Abstract Design

4.2 Implementation

The IntelliMod will majorly work on the Model-Based Reflexive Agent system. The compost will be prepared in a semi-closed environment. This environment is an extension of the one mentioned in Reference [5].
Some major hardware and software components will be :

1. **Temperature sensors:** Thermometers will be installed in the system to sense the temperature level at different levels of the soil. During the decomposition phase of composting, which goes on for 15 to 30 days, Temperature rises to 60 degrees in the first subphase and varies from 65 to 70 degrees in the second subphase. This data will be fed in the form of “condition - action rules” in the model-based part of the IntelliMod. In the next 30 to 60 days, the temperature drops gradually as the compost stabilises and cooling effect is observed.

2. **Moisture sensors**: The first type of moisture sensors will be connected to the IntelliMod system to sense trapped water content in soil particles and Second type of Moisture sensors will be installed to catch the surrounding environment's moisture content. During the first phase of composting the moisture should be 50% to 60%. Anytime the moisture goes higher than 60%, it makes the process anaerobic which would lead to contamination of the compost.

3. **Fans**: The fans installed in the system will have the ability to move at different speeds which will be provided by the agent. These act ac cooling actuators connected to the agent.

4. **Sprinkler**: Whenever the agent senses less moisture content in the compost materials, the sprinklers should go on. The Moisture sensors will signal to stop the sprinklers whenever the content is greater than 60% at any stage of the composting process.

5. **Natural Heater**: During summer days in India, Sunlight can be trapped using solar panels and the heat can be used to maintain temperature for the compost in cold days. If the temperature starts dropping below 60 degrees before 15 to 30 days i.e before the completion of the decomposition phase of composting, the heater will be turned on.

An optional software can be a Whether Calculation system (through database) will only be applicable in open composting systems. It will be a continuous cloud-based database system which will require heavy computing. The learning agent can pre-compute any major rainfall or thunderstorm and calculate the temperature and humidity requirements accordingly.

The critic will be responsible for providing the agent, data log of performance of the agent based on the state sensed by the sensor. The Agent computes hand-in-hand the final actions by taking into consideration it's condition-action rules, learning and the performance element. This real-time calculation can be done using a software built on any latest language like python. The basic composting process would be hardcoded in the system and the learning agent would be coded using learning algorithms in python.

4.3 Challenges

The Installation of the IntelliMod system can be cost-effective if the cost of solar panels is reduced. Other hardware components do not pose a challenge and are readily available.

As high-quality software is used, software maintenance cost adds to the total production of IntelliMod which is a challenge towards implementing the agent in India. The agent will require a proper database management system to keep record of all the materials used in compost and the log of environmental conditions within the system.

5. Conclusion

The process of composting is complex and depends on many other factors but through this model, the work aims to provide a futuristic view of artificial intelligence in the field of agriculture and the building of ‘smart’ cities. In India, composting is an alternative to landfills. This is also because of economical and environmental reasons. This saves a lot of money from buying fertilisers. So, small scale application of the IntelliMod agent in India can be a start of something revolutionary.

6. References

[1] Anisha Bhatia, “Fighting India’s Garbage Crisis: All About Composting” ndtv.com, Mar. 19, 2019. [Online]. Available:https://swachhindia.ndtv.com/fighting-indias-garbage-crisis-all-about-composting-32044/ [Accessed: Oct. 11, 2020].

[2] Koka, Ramyakrishna & Pilli, Kiran & Das, Shreya & Kaila, Tara. Chapter -2 *Municipal Solid Waste: Management and MSW Compost Impact on Soil Fertility* 2020

[3] Michael Wooldridge, *An Introduction to MultiAgent Systems* 2nd. ed. Wiley Publishing, 2009

[4] Loeb Classical Library, 1934 Available : http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Cato/De_Agricultura/A*.html[Accessed: Oct. 11, 2020].

[5] Nikoloudakis, Yannis, et al. , "Composting as a Service: A Real-World IoT Implementation." *Future Internet* Oct. 2018.

[6] Jordão, M.D.L.; de Paiva, K.; Firmo, H.T.; Inácio, C.T.; Filho, O.C.R.; Lima, T.A.E. Low-cost automatic station for compost temperature monitoring. *Revista Brasileira de Engenharia Agrícola e Ambiental* **2017**.

[7] Rahane, S.B.; Engg, E.; College, A. Design of Wireless Sensor Node and Time Contoured Control Scheme for a Composting Process. *Int. J. Adv. Eng. Technol.* 2011.

[8] Capelli, L., Sironi, et al. “Electronic Noses For Environmental Monitoring Applications” *Sensors* Feb 2014.