

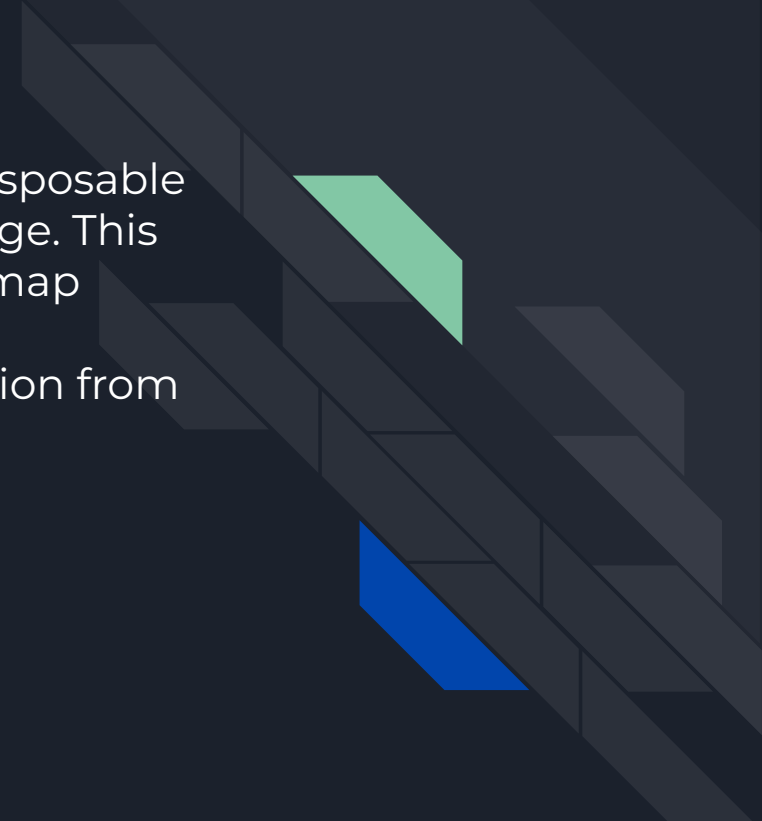
Study of the Ecosystem of Circular and Smart Disposables in the Health Sector and Design of an Innovative Solution

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Introduction

In the ever-evolving landscape of healthcare **sustainability**, the effective **management** of disposable healthcare waste emerges as a critical challenge. This presentation outlines a groundbreaking roadmap aimed at revolutionizing healthcare waste management, offering a **comprehensive** solution from waste generation to responsible disposal.



- *Project Aim:* Develop an embedded device solution for efficient healthcare waste management and recycling.
- *Global Impact:* Healthcare plastic products usage expected to reach 55 billion € by 2025.
- *Current Disposal:* Majority in landfills or incineration, despite recyclable potential.

Medical Waste Lifecycle



Generate

The moment an item is used and needs disposal.

Sort

Collection and in-house segregation of generated waste.

Contain

The collected waste is placed into containers at a centralized storage point.

Transport

Specialized vehicles transport the containerized waste.

Treat

The process where waste is treated at a Common Biomedical Waste Treatment Facility.

Dispose

The final phase involving recycling and landfilling.

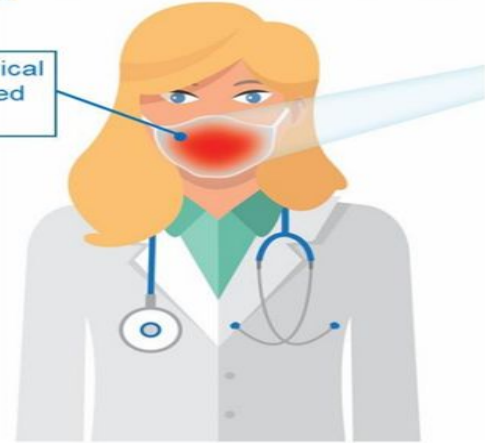
Conventional face mask



- *Standard filtration efficiency*

Next generation face mask

Smart hierarchical
nanostructured
material



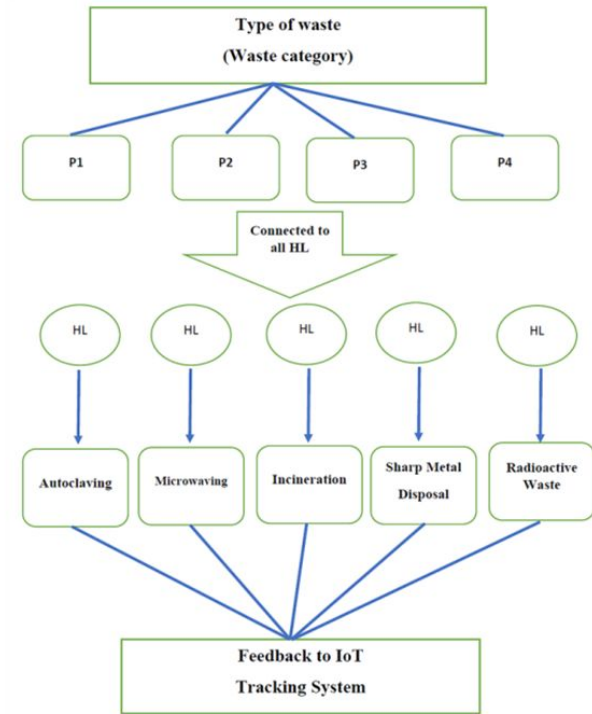
- *Light activation*
- *On-demand pathogen elimination*
- *Effective filtration*
- *Moisture control*
- *Digitally personalized*

Sorting and categorisation

Surinder Gopalrao Wawale et al.'s Study proposed a type of waste categorisation using a fuzzy-based system which according uses a color coding for bags of different waste. Then it categorizes it in terms of four parameters as described below:

- Cost generator
- Health risk
- Bio/Non-bio-degradable
- Environmental effect

Hidden layer (HL) in the fuzzy system chooses appropriate processes :



Sorting and categorisation

This article is about Manual Waste Sorting
Analysis Inspired by the manual sorting process :

- Studied manual waste sorting tasks
- Analyzed cognitive and sensorimotor characteristics

Using touchscreen monitors to view waste on a
conveyor belt





Containerisation

Hao Liu, Zhong Yao introduced an RFID Solution that collects medical waste from various departments, classifying it, and packaging it according to the classification standards. After pasting the RFID electronic tag and weighing, the RFID readwrite device records waste category, source, and weight on the package.



Transport

Waste Transportation Process by Hao Liu, Zhong Yao's solution is to :

- Equip each vehicle with RFID tags to record specific informations (vehicle category, unit, lines, license, plate number, driver, contact information, and date).
- Real-time tracking of vehicle trajectories is done using GPS

Treatment and
disposal

Autoclaving

Incineration

Chemical

Disposal

1. **Incineration:**

- Efficient thermal treatment in controlled environments, suitable for sharps, contaminated materials, and infectious waste.

2. **Autoclaving:**

- Sterilization through high-pressure steam, ideal for instruments, laboratory waste, and certain infectious materials.

3. **Chemical Disinfection:**

- Neutralization of pathogens using disinfectants, applicable to various contaminated materials, ensuring safe disposal.

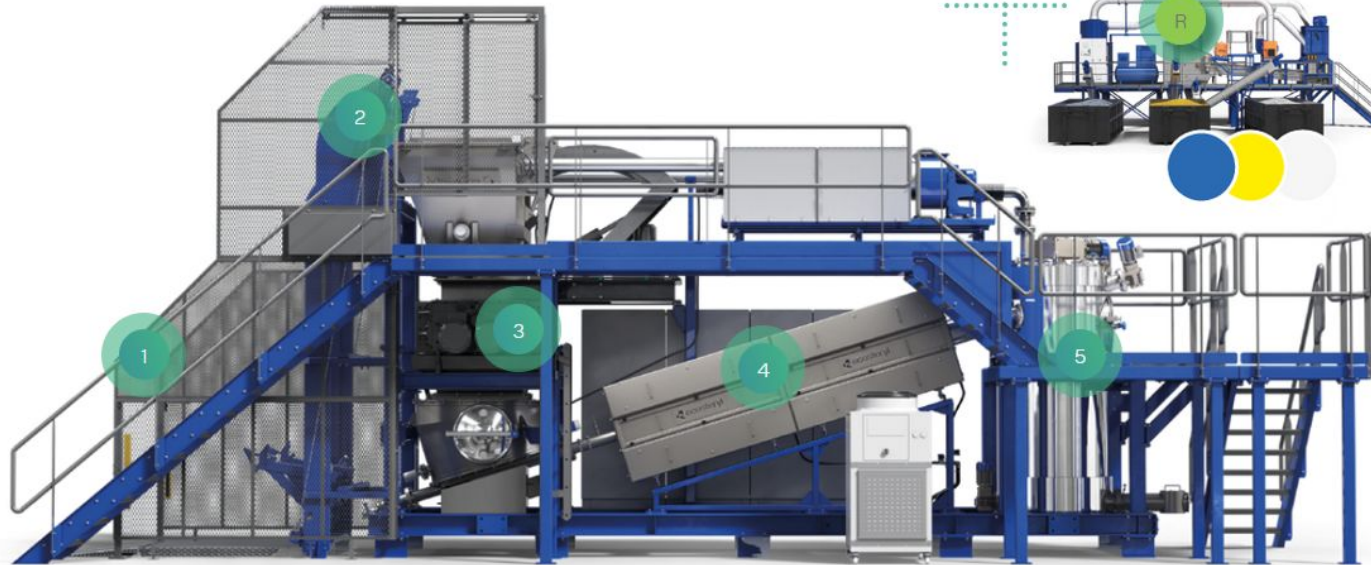
4. **Encapsulation:**

- Safe containment of sharps and potentially infectious items, reducing risks during disposal.

Existing commercial All-in-one solution

The process

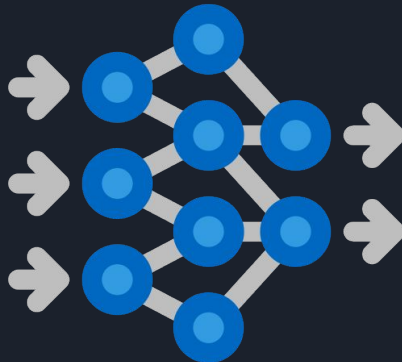
A fully electric dry heat process



Sorting and circular economy thanks to R-Steryl

Upgrade of the process via Automation

Addressing Lifecycle Reduction: To initiate a significant reduction in the medical waste lifecycle, a pivotal strategy involves automating manual sorting and categorizing steps, replacing them with an efficient automated process.



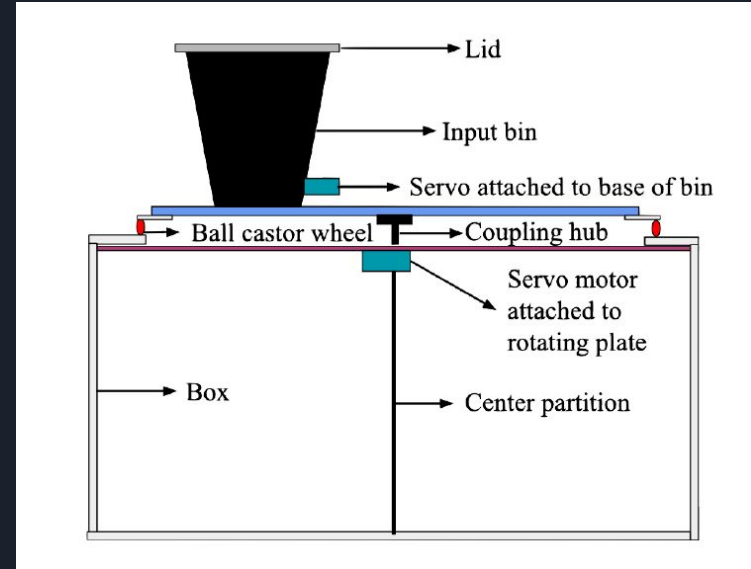
Automation Through Machine Learning:

- **Methodology:** Leveraging machine learning and deep learning techniques has emerged as a prominent approach, as extensively explored in the study conducted by Zhou et al.
- **Focus on Medical Waste Subset:** The study specifically delves into a subset of medical waste, emphasizing the role of automation in the classification process.

Practical application

Mechanizing Sorting Processes:

- **Practical Application:** Ninad Mehendale et al proposes mechanizing sorting and categorization processes post-abstract classification using deep learning techniques.
- **Embedded System with AlexNet:** An embedded system involving AlexNet architecture, Raspberry Pi4, IR sensor, Pi camera, USB light, and servo motors is introduced for practical implementation.





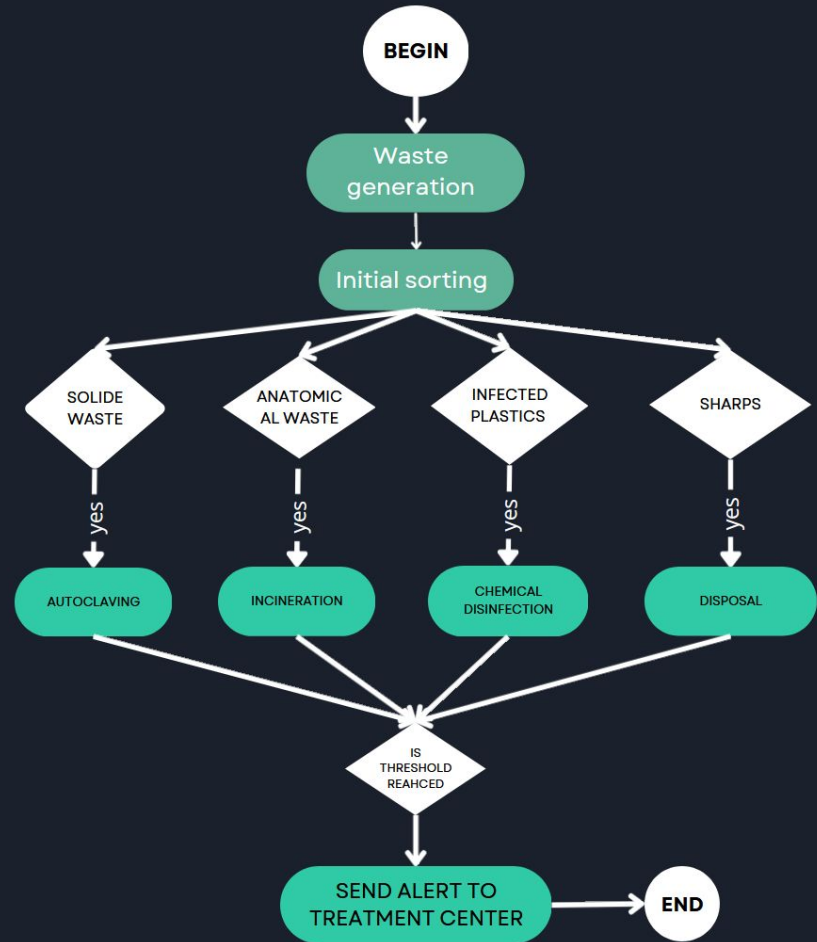
Our Solution

- **Challenge:** Addressing the complexities of healthcare waste management.
- **Innovation:** Our solution is a fusion and convergence of diverse methodologies, traditionally handled in isolation across the waste lifecycle.
- **Integration:** Rather than treating waste processes as isolated phases, our approach seamlessly integrates and upgrades waste generation, categorization, containerisation, transportation.
- **Advantages:** Offers a comprehensive lifecycle upgrade, optimizing efficiency, safety, and sustainability.
- **Key Message:** A solution that transforms healthcare waste management paradigm by unifying and enhancing each phase simultaneously.

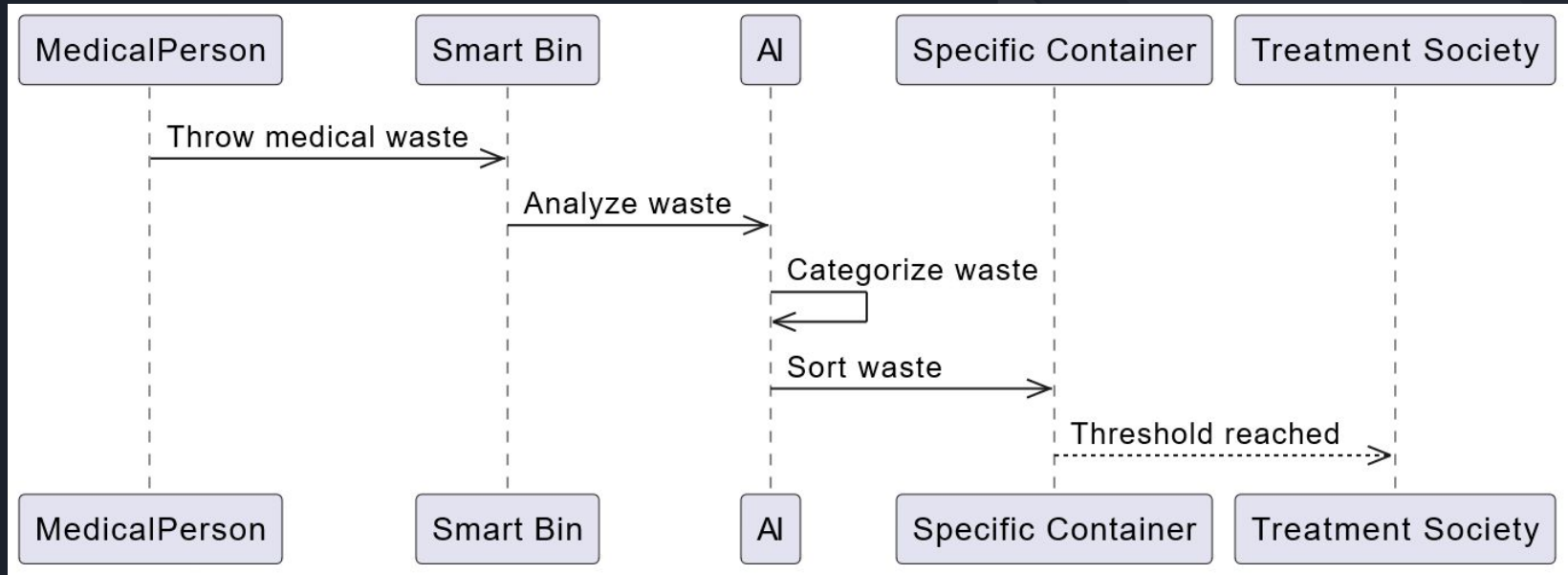


Flowchart of the solution

The solution primarily focuses on integrating the three key components, each of which already has its distinct functional solution, to create a fully autonomous system capable of comprehensive resolution.



UML sequence diagram of the system



Solution Overview: Enhancing Waste Management

1. Categorization:

Leveraging Existing Algorithms: Our approach starts with the utilization of advanced algorithms developed by the researchers cited earlier. These algorithms, rooted in machine learning and deep learning, facilitate the precise categorization of medical waste, addressing the nuances presented by variations in waste types across different contexts.

Solution Overview: Enhancing Waste Management

2. Containerization:

Efficient Mechanism: Once waste is categorized, our solution incorporates an innovative and efficient containerization mechanism. This mechanism ensures the safe placement of identified waste into the corresponding containers. By seamlessly integrating technology and automation, we enhance the accuracy and speed of the containerization process, reducing the risk of errors and promoting safety in waste handling.

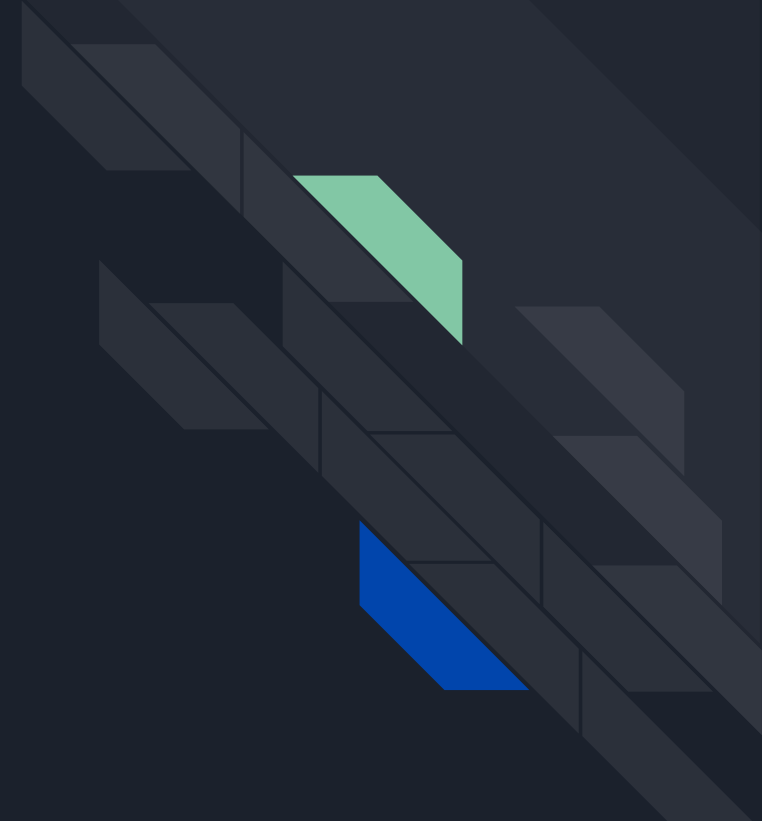
Solution Overview: Enhancing Waste Management

3. Transport Call:

Monitoring Process Implementation: To further streamline the waste management process, our solution introduces a robust monitoring system. This system continuously tracks the status of waste containers and, when necessary, initiates a transport call. This automated process efficiently notifies the appropriate treatment center, ensuring timely waste pickup and correct disposal. The integration of real-time monitoring adds an extra layer of efficiency, contributing to a responsive and adaptive waste management system.

Performance indicators

- Accuracy
- Precision
- Economic gain
- overall efficiency
relatively to a manual
system



Futur?

- **Extend** the system beyond the identified lifecycle stages
- **enhance** the datasets to facilitate improved recognition capabilities
- **optimize** the mechanized system for enhanced performance



Thank you for your time!

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