King Abdulaziz University

Faculty of Computing & Information Technology
Department of Computer Science
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Prepared for: Dr. Mai Nassier

مُرجَان
MURJAN

Ecological expert system Project

Artificial Intelligence

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Submit Date: 25/4/2024		

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1. Task Assignment

1.1 Tasks Performed for Murjan Project

- Information gathering
- Writing introduction
- Building Knowledge Base
- Composing Knowledge Base and rules based on diseases
- Writing code
- Acquiring references

1.2 Team member's percentage contribution to each task

Student's Name	ID	contribution
Shahad Duqayl Salem (Leader)	21*****	33.33%
Bashayer Khalid	21*****	33.33%
Joud Jamal Alkishi	20*****	33.33%

Table 1

2. Introduction

2.1 Purpose of the chosen Expert System

Coastal pollution is one of the most serious environmental issues affecting coastal towns across the world. With the invasion of plastic, glass, metal, paper, and other waste products, marine ecosystems and coasts are at risk of contamination, endangering marine life, human health, and the environment as a whole.

The pressing need for beach cleanup and precise waste sorting prompted the development of intelligent technology to properly solve this issue. The expert system intends to use technology to automatically collect and classify waste. The robot, equipped with a variety of sensors and clever algorithms, will identify and classify waste such as glass, plastic, metal, paper, fabrics and others. This technique allows us to improve waste collection efficiency while also mitigating the negative effects of coastal pollution on the ecosystem and marine life **(1)**.

2.2 Users of the system

The primary users of the system, who will benefit directly from its implementation, include:

- **Municipal Authorities**: Responsible for maintaining cleanliness in coastal towns, they will benefit from the enhanced efficiency and effectiveness of automated waste collection and sorting.
- **Environmental Organizations**: These groups will be able to leverage the data and results from the system to support their conservation efforts and policy advocacy.
- **Tourists and Beachgoers**: They will enjoy cleaner beaches, improving their overall experience and contributing to public health and safety.
- **Local Communities**: Residents living near coastal areas will benefit from a cleaner environment, which can improve quality of life and reduce health risks associated with pollution.
- **Research Institutions**: These institutions can use the data collected by the system for further studies on coastal pollution and the effectiveness of various waste management strategies.

2.3 Experts

The system's purpose is to autonomously collect and sort beach waste, categorizing it into different waste types such as glass, plastic, metal, paper, fabrics, and others. Additionally, it identifies the suitable trash container color using modern sensors and clever algorithms.
Experts in the field are critical for providing the necessary knowledge and expertise to develop and refine this system. These experts include:

- **Marine Biologists**: They provide insights into the impact of different types of waste on marine ecosystems and help develop strategies to mitigate these effects.
- **Environmental Engineers**: They contribute their knowledge on waste management techniques and the design of effective waste collection systems.
- **Robotics Engineers**: They bring expertise in developing and programming robots, ensuring that the machines can efficiently perform the tasks of waste identification and sorting.
- **Computer Scientists**: They focus on the development of algorithms and artificial intelligence systems that enable the robots to accurately classify and sort waste materials.
- **Environmental Policy Makers**: They offer guidance on regulatory requirements and best practices for waste management and environmental protection.

2.4 Resources will be used

We used research and studies on waste sorting robots to understand the mechanism and how to detect differences in collected waste.

3. Body

3.1 A list of rules

1- If the robot's answers are as follows:

- No, I did not pick up a waste item, and want to know the appropriate trash container for it.

➞ Then the answer is "Understood, have a great day"

2- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- Yes, it generates a magnetic field.
- Yes, it has integrated electronic circuits.

➞ Then the appropriate trash container is **Gray** (It is electronics)

3- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- Yes, it generates a magnetic field.
- No, it does not have integrated electronic circuits.

➞ Then the appropriate trash container is **Pink** (it is metal)

4- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- Yes, it consists of organic molecules.

➞ Then the appropriate trash container is **Fuchsia** (it is food)

5- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- Yes, it is easy to break the item.

➞ Then the appropriate trash container is **Orange** (it is glass)

6- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- Yes, it is fabric.

➞ Then the appropriate trash container is **Purple** (it is cloth)

7- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- Yes, it consists of hard materials.
- No, it is not a combustible material.

➞ Then the answer is "It's not a waste material, Please return it to the beach."

Note: it is maybe a rock or a seashell.

8- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- Yes, it consists of hard materials.
- Yes, it is a combustible material.
- No, it does not absorb the water.

➞ Then the appropriate trash container is **Blue** (it is plastic)

9- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- Yes, it consists of hard materials.
- Yes, it is a combustible material.
- Yes, it absorbs the water.

➞ Then the appropriate trash container is **Brown** (it is wood)

10- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- No, it does not consist of hard materials.
- Yes, it is transparent.

➞ Then the appropriate trash container is **Blue** (it is plastic)

11- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- No, it does not consist of hard materials.
- No, it is not transparent.
- Yes, it is water-resistant.

➞ Then the appropriate trash container is **Yellow** (it is rubber)

12- If the robot's answers are as follows:

- Yes, I picked up a waste item and wanted to know the appropriate trash container for it.
- No, it does not generate a magnetic field.
- No, it does not consist of organic molecules.
- No, it is not easy to break the item.
- No, it is not fabric.
- No, it does not consist of hard materials.
- No, it is not transparent.
- No, it is not water-resistant.

➞ Then the appropriate trash container is **Green** (it is paper)

3.2 The Technique used to acquire knowledge from the system

We applied the forward chaining technique using the Python Experta library

3.3 The System's Flowchart

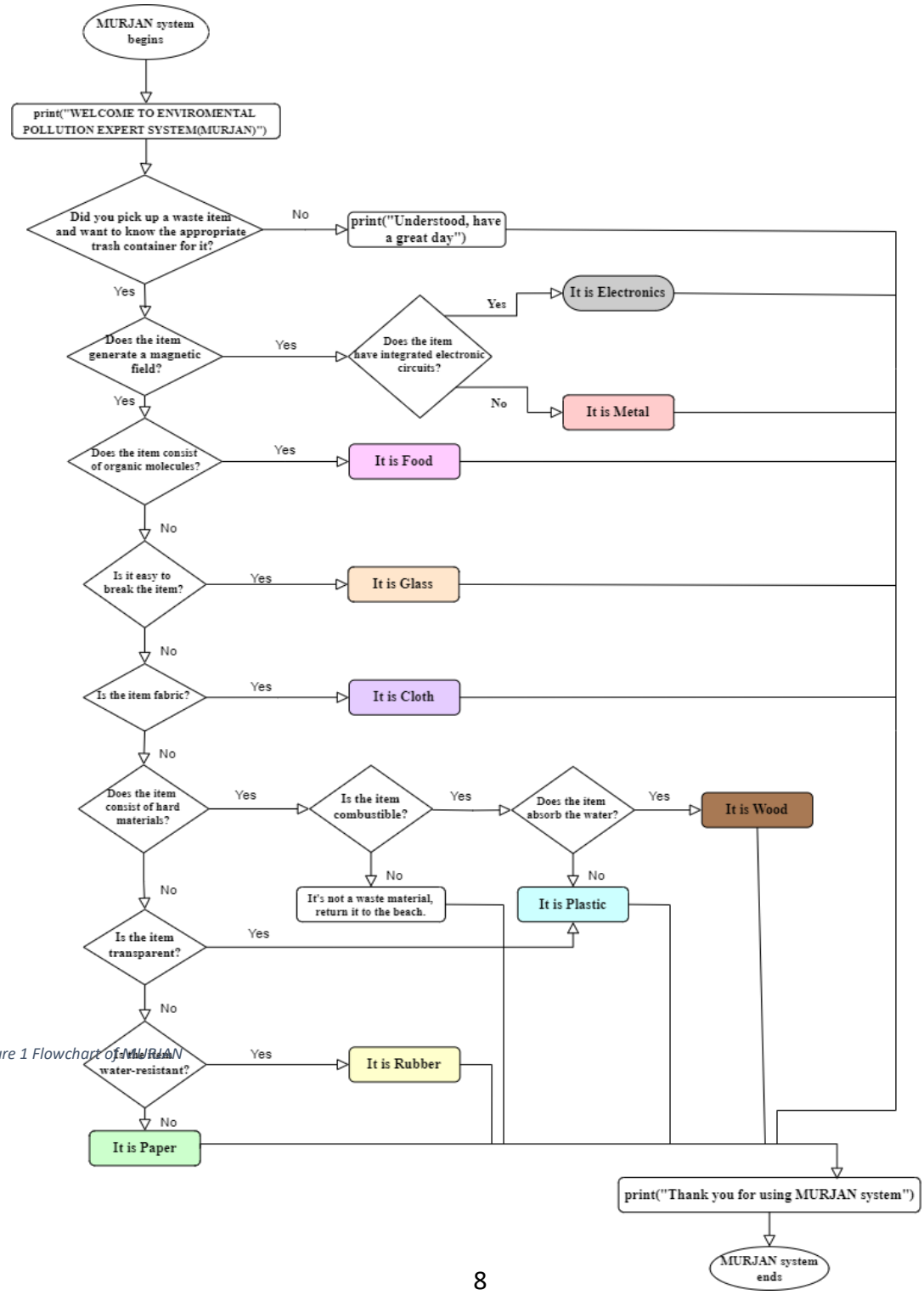

Figure 1 Flowchart of MURJAN

4. References

(1) Satav, A. G., Kubade, S., Amrutkar, C., Arya, G., & Pawar, A. H. (2023, April 2). *A state-of-the-art review on robotics in waste sorting: scope and challenges.* Retrieved from ResearchGate: https://www.researchgate.net/publication/370582979_A_state-of-the-art_review_on_robotics_in_waste_sorting_scope_and_challenges

(2) Ang, F., Gabriel, M. K., Sy, J., Tan, J. J., & Abad, A. (2013). AUTOMATED WASTE SORTER WITH MOBILE ROBOT DELIVERY WASTE. Manila, Philippines: De La Salle University. Retrieved from https://d1wqtxts1xzle7.cloudfront.net/81611776/HCT-II-016-libre.pdf?1646275580=&response-content-disposition=inline%3B+filename%3DAutomated_Waste_Sorter_with_Mobile_Robot.pdf&Expires=1713798306&Signature=RZJ4jYUCmfieb0mRnfNsUXQmRt7gt9NIX-1PJftVTe3Diegcqpi

(3) Chen, X., Huang, H., Liu, Y., Li, J., & Liu, M. (2022). *Robot for automatic waste sorting on construction sites* (Vol. 141). China: Elsevier B.V. Retrieved from https://doi.org/10.1016/j.autcon.2022.104387

(4) Koskinopoulou, M., Raptopoulos, F., Papadopoulos, G., Mavrakis, N., & Maniadakis, M. (2021, June). Robotic Waste Sorting Technology: Toward a Vision-Based Categorization System for the Industrial Robotic Separation of Recyclable Waste. *IEEE Robotics & Automation Magazine, 28*(2), 50-60. Retrieved from https://doi.org/10.1109/MRA.2021.3066040

5. Appendices

5.1 Source Code

```
from experta import *

# Define a Fact subclass for trash containers
class TrashContainer(Fact):
    pass

# Global variable to store the item type
item_type = None

# Define the expert system class inheriting from KnowledgeEngine
class ExpertSystem(KnowledgeEngine):
    # Rule to start the system
    @Rule()
    def start_system(self):
        global item_type
        print("------------------------------------------------------------------------")
        print("== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==")
        print("------------------------------------------------------------------------\n")
        while True:
            answer = input("➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no):
").lower()
            if answer == "no":
                print("Understood, have a great day!")
                print("\n-----------------------------------------------")
                print("== 🐚 Thank you for using MURJAN system 🐚 == ")
                print("-----------------------------------------------")
                self.reset()
                break
            elif answer == "yes":
                self.declare(TrashContainer(question="magnetic_field"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about magnetic field
    @Rule(TrashContainer(question="magnetic_field"))
    def ask_magnetic_field(self):
        global item_type
        while True:
            answer = input("\n➤ Does the item generate a magnetic field? (yes/no): ").lower()
            if answer == "yes":
                self.declare(TrashContainer(question="integrated_electronic"))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="organic"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about integrated electronics
    @Rule(TrashContainer(question="integrated_electronic"))
    def ask_integrated_electronic(self):
        global item_type
        while True:
            answer = input("\n➤ Does the item have integrated electronic circuits? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Electronic"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                item_type = "Metal"
                self.declare(TrashContainer(type=item_type))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")
```

```
    # Rule to ask about organic molecules
    @Rule(TrashContainer(question="organic"))
    def ask_organic(self):
        global item_type
        while True:
            answer = input("\n‣ Does the item consist of organic molecules? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Food"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="breakable"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about breakability
    @Rule(TrashContainer(question="breakable"))
    def ask_breakable(self):
        global item_type
        while True:
            answer = input("\n‣ Is the item easy to break? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Glass"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="fabric"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about fabric
    @Rule(TrashContainer(question="fabric"))
    def ask_fabric(self):
        global item_type
        while True:
            answer = input("\n‣ Is the item fabric? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Cloth"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="hard_materials"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about hard materials
    @Rule(TrashContainer(question="hard_materials"))
    def ask_hard_materials(self):
        global item_type
        while True:
            answer = input("\n‣ Does the item consist of hard materials? (yes/no): ").lower()
            if answer == "yes":
                self.declare(TrashContainer(question="combustible"))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="transparent"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")
```

```
    # Rule to ask about combustibility
    @Rule(TrashContainer(question="combustible"))
    def ask_combustible(self):
        global item_type
        while True:
            answer = input("\n➤ Is the item combustible? (yes/no): ").lower()
            if answer == "yes":
                self.declare(TrashContainer(question="absorb_water"))
                break
            elif answer == "no":
                print("It is not a waste material. Please return it to the beach.")
                self.reset()
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about water absorbance
    @Rule(TrashContainer(question="absorb_water"))
    def ask_absorb_water(self):
        global item_type
        while True:
            answer = input("\n➤ Does the item absorb water? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Wood"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                item_type = "Plastic"
                self.declare(TrashContainer(type=item_type))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about transparency
    @Rule(TrashContainer(question="transparent"))
    def ask_transparent(self):
        global item_type
        while True:
            answer = input("\n➤ Is the item transparent? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Plastic"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                self.declare(TrashContainer(question="water_resistant"))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")

    # Rule to ask about water resistance
    @Rule(TrashContainer(question="water_resistant"))
    def ask_water_resistant(self):
        global item_type
        while True:
            answer = input("\n➤ Is the item water resistant? (yes/no): ").lower()
            if answer == "yes":
                item_type = "Rubber"
                self.declare(TrashContainer(type=item_type))
                break
            elif answer == "no":
                item_type = "Paper"
                self.declare(TrashContainer(type=item_type))
                break
            else:
                print("Invalid input. Please enter 'yes' or 'no'.")
```

```
    # Rule to determine trash container color based on item type
    @Rule(OR(
        TrashContainer(type="Metal"),
        TrashContainer(type="Food"),
        TrashContainer(type="Electronic"),
        TrashContainer(type="Glass"),
        TrashContainer(type="Cloth"),
        TrashContainer(type="Wood"),
        TrashContainer(type="Plastic"),
        TrashContainer(type="Rubber"),
        TrashContainer(type="Paper")
    ))
    def determine_trash_container_color(self):
        global item_typecontainer_color.get(item_type, "Sorry, we couldn't determine the appropriate trash container
color."))
        else:
            print("Sorry, we couldn't determine the appropriate trash container color.")
        print("\n---------------------------------------------")
        print("== 🐚 Thank you for using MURJAN system 🐚 == ")
        print("---------------------------------------------")
        self.reset()

# Instantiate the expert system
expert_system = ExpertSystem()

# Run the expert system
expert_system.reset()
expert_system.run()
```

Figure 2 | Source Code of MURJAN System

5.2 Screenshots & Results of MURJAN System

```
------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): No
Understood, have a great day!

---------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
---------------------------------------------
```

Figure 5 | Rule#1 Output

```
------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): Yes

➤ Does the item have integrated electronic circuits? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Electronic
Container color 🎨:  Gray trash container

---------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
---------------------------------------------
```

Figure 4 | Rule#2 Output

```
------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): Yes

➤ Does the item have integrated electronic circuits? (yes/no): No

Determining item type & trash container color ⏳...

Item type 🧩:  Metal
Container color 🎨:  Pink trash container

---------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
---------------------------------------------
```

Figure 3 | Rule#3 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Food
Container color 🎨:  Fuchsia trash container

-------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
-------------------------------------------
```

Figure 8 | Rule#4 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Glass
Container color 🎨:  Orange trash container

-------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
-------------------------------------------
```

Figure 7 | Rule#5 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): No

➤ Is the item fabric? (yes/no): No

➤ Does the item consist of hard materials? (yes/no): Yes

➤ Is the item combustible? (yes/no): No
It is not a waste material. Please return it to the beach.
```

Figure 6 | Rule#6 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): No

➤ Is the item fabric? (yes/no): No

➤ Does the item consist of hard materials? (yes/no): Yes

➤ Is the item combustible? (yes/no): Yes

➤ Does the item absorb water? (yes/no): No

Determining item type & trash container color ⏳...

Item type 🧩:  Plastic
Container color 🎨:  Blue trash container

-----------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
-----------------------------------------------
```

Figure 9 | Rule#7 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): No

➤ Is the item fabric? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Cloth
Container color 🎨:  Purple trash container

-----------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
-----------------------------------------------
```

Figure 10 | Rule#8 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): No

➤ Is the item fabric? (yes/no): No

➤ Does the item consist of hard materials? (yes/no): Yes

➤ Is the item combustible? (yes/no): Yes

➤ Does the item absorb water? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Wood
Container color 🎨:  Brown trash container

---------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
---------------------------------------------
```

Figure 11 | Rule#9 Output

```
--------------------------------------------------------------------
== 🐚 WELCOME TO ENVIRONMENTAL POLLUTION EXPERT SYSTEM (MURJAN) 🐚 ==
--------------------------------------------------------------------

➤ Did you pick up a waste item and want to know the appropriate trash container for it? (yes/no): Yes

➤ Does the item generate a magnetic field? (yes/no): No

➤ Does the item consist of organic molecules? (yes/no): No

➤ Is the item easy to break? (yes/no): No

➤ Is the item fabric? (yes/no): No

➤ Does the item consist of hard materials? (yes/no): No

➤ Is the item transparent? (yes/no): Yes

Determining item type & trash container color ⏳...

Item type 🧩:  Plastic
Container color 🎨:  Blue trash container

---------------------------------------------
== 🐚 Thank you for using MURJAN system 🐚 ==
---------------------------------------------
```

Figure 12 | Rule#10 Output

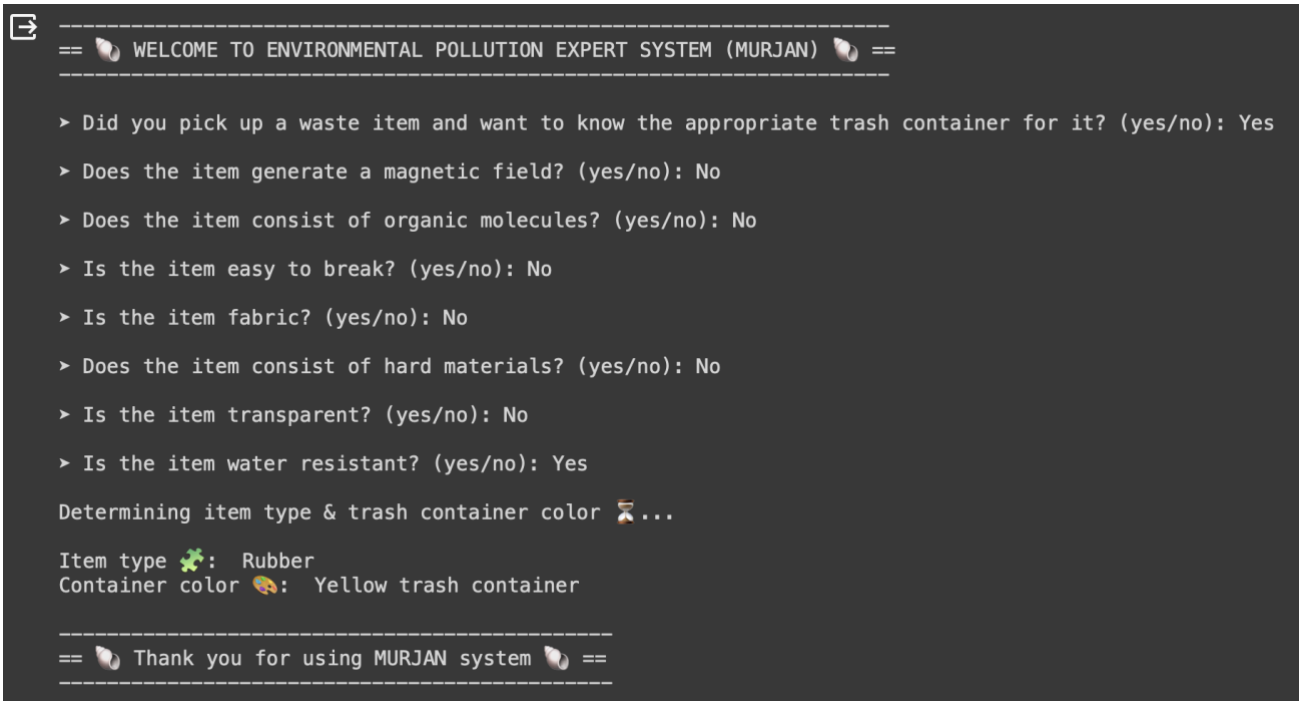

Figure 13 | Rule#11 Output

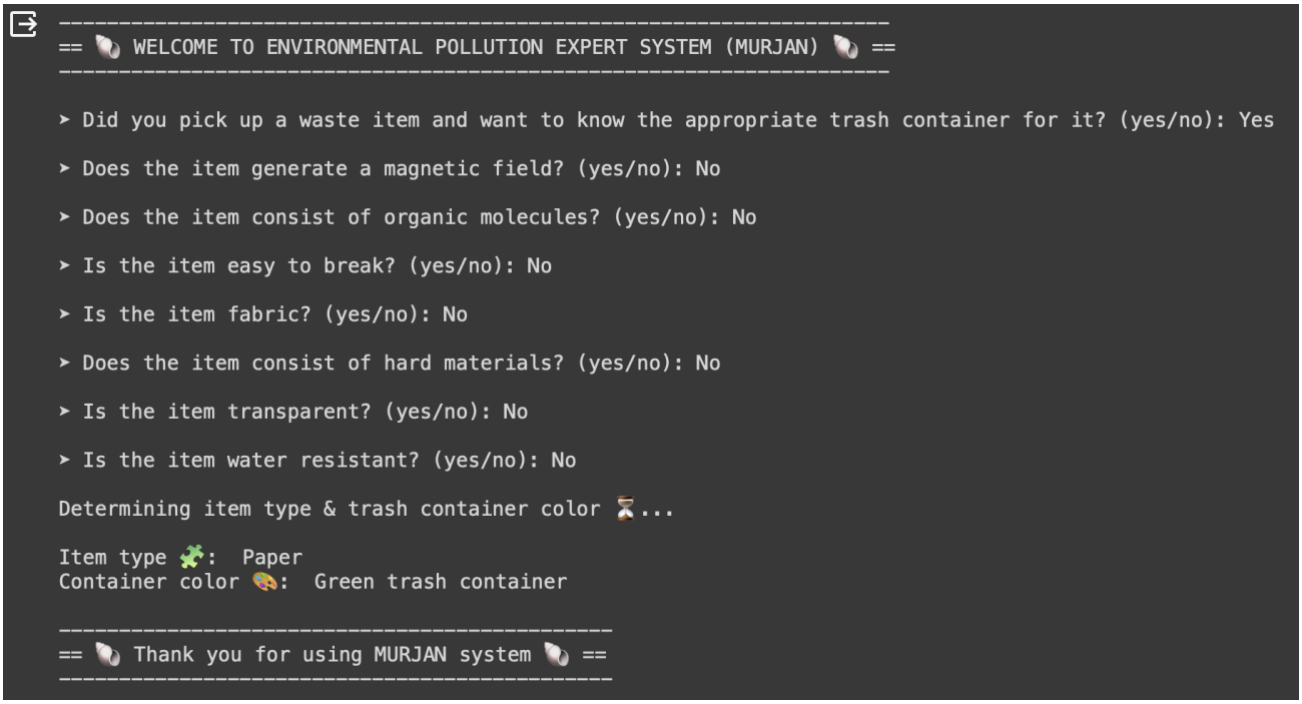

Figure 14 | Rule#12 Output