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Original Article

Simulation of An Automatic System of Robotics for Artificial Animated Being Manufacturing Using AnyLogic Simulation Software

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Abstract *- In this model, a Robot is employed to place raw artificial animated beings into three different tanks according to a specific sequence. Each artificial animated being must remain in each tank for a designated period, falling within a specified minimum and maximum duration. Should the maximum time limit be surpassed, the artificial animated being is deemed overcooked and discarded. Conversely, upon completing the cycle through the third tank, the artificial animated being transforms into a living being and departs. The robot, which can be considered as a crane, is designed as an agent comprising four statecharts: three manage the degrees of freedom, while one serves as the overarching controller. It features two types of interfaces: an Application Programming Interface (API) offering functions such as moveTo(), stop(), etc., and flowchart objects named UseRobot, applicable within Enterprise Library flowcharts, as demonstrated in this model.*

Keywords *- Artificial Intelligence, Robotics, Automatic system, Simulation model, Any Logic.*

1. Introduction

Artificial Intelligence (AI) denotes the advancement of computer systems capable of executing tasks traditionally requiring human intelligence. These tasks encompass learning, reasoning, problem-solving, natural language comprehension, speech recognition, and visual perception. AI technologies strive to replicate human cognitive functions and streamline intricate processes. The scope of AI is extensive, with definitions varying across disciplines. To computer scientists, AI involves crafting programs that demonstrate intelligent behavior, encompassing tasks like intelligent planning.

For engineers, AI entails constructing machines capable of executing actions typically performed by humans. It is vital to understand that programs, machines, and models developed by computer scientists, engineers, and cognitive scientists do not possess human intelligence; rather, they exhibit intelligent behavior [1]. Intelligence remains a relative concept; no system can achieve “perfect intelligence.” Instead, systems may differ in intelligence based on their ability to acquire diverse knowledge, reorganize beliefs and skills in intricate ways, or adapt efficiently [2].

Advancements in embedded computers, sensors, and other emerging technologies have enabled the integration of artificial intelligence into various entities, including machines, buildings, and robots [3]. The integration of AI into robotics primarily aims to enhance certain abilities of industrial robots. While experts and scientists are still exploring the full potential of robotics and AI, current use cases indicate a promising future [4].

Artificial intelligence-powered devices get better over time as they do useful activities on a regular basis. Automation powered by AI is becoming essential in a number of industries, including marketing, finance, data analysis, and healthcare. However, as AI becomes commonplace, significant concerns about how it will affect consumers, companies, and the economy are being raised. Workers are growing more curious about how AI will impact their wages and jobs. Businesses are increasingly looking into how to invest in the robotics prospects that AI presents [5].

The automation of AI is widely recognized to have enormous potential to transform manufacturing processes and significantly contribute to addressing important global concerns. Businesses that operate in a variety of industries generally share this viewpoint. Numerous advantages come with AI automation in production, such as improved productivity, efficiency, and quality assurance. Manufacturers may enhance overall operational performance, reduce waste, and optimize production processes by utilizing AI technologies. Furthermore, the creation of intelligent factories with adaptive manufacturing capabilities-where production systems can instantly adjust to shifting demands and conditions is made possible by AI-powered automation. Automation powered by AI also holds promise for tackling major global issues, including workforce optimization and resource efficiency [6].

Given that Robotics involves the intersection of perception and action, AI plays a crucial role in ensuring that this connection is intelligent. AI tackles fundamental questions such as what knowledge is necessary for various aspects of cognition, how to represent that knowledge, and how to utilize it effectively [7, 8]. Robotics poses challenges to AI by necessitating interaction with real-world objects. Techniques and representations developed for cognitive tasks, often in simplified environments, may not adequately address these challenges. Robots integrate mechanical actuators, sensors, and computational systems, with AI contributing significantly to each component [9].

AI and Robotics share a common origin and have a relatively long history of interaction and scholarly discourse. Both fields emerged around the same time in the 1950s, and initially, there was little distinction between them. This lack of differentiation stemmed from the concept of an “intelligent machine,” which naturally encompasses robots and Robotics. While it is true that not all machines are robots, and AI also encompasses virtual agents (agents not physically embodied in machines), many of the technical challenges and solutions required for robot design are not typically addressed in AI research [10].

Industrial Robotics represents a convergence point between AI, Robotics, and industrial robotics. As was already mentioned, these fields were quite early on and were not well defined. The current state of industrial robotics research extends into the field of service robotics and focuses on the intelligent and safe control of industrial manipulators. The principle of automated control is often utilized in industrial robotics methodologies. The intersection of AI, robotics, and industrial robotics is represented by industrial robotics. As was previously indicated, these fields were not well defined in their early stages. Currently, research in industrial robotics and service robotics centers on the intelligent and safe control of industrial manipulators. Automatic control theory is a major source of inspiration for industrial robotics methodologies. Numerous feedback systems are frequently used to simulate the interaction between robots and their surroundings, and optimization theory and numerical techniques are frequently employed in these modeling techniques.

The rapid advancement of AI, machine learning, robotics, and automation is driving profound transformations in industries and societies worldwide. These changes are poised to revolutionize how to work, live, and interact with one another, surpassing anything seen in human history in terms of speed and scale. While this new industrial revolution holds the promise of enhancing and improving our lives and societies, it also carries the potential for significant disruptions to our way of life and societal norms. The window for understanding the impact of these technologies and mitigating their negative effects is rapidly closing. Humanity must adopt a proactive approach to managing this new industrial revolution rather than merely reacting to its consequences [11]. Drawing on advancements in mechatronics, electrical engineering, and computing, robotics is evolving to possess increasingly sophisticated sensorimotor functions, granting machines the capability to adapt to dynamic environments. Traditionally, industrial production systems revolved around machines calibrated to their environment and tolerating minimal variations [12].

Engineering and manufacturing processes, as well as systems designs, are often fraught with challenges such as dynamism, chaotic behaviors, and complexity. However, recent advancements in technology have transformed the approaches of many engineering and manufacturing professionals [13]. Indeed, the advent of big data, cloud computing, high computational speed, and artificial intelligence approaches like machine learning and deep learning have completely changed how experts in a variety of industries approach their work. These technologies enable the processing and analysis of vast amounts of data, allowing for deeper insights, more accurate predictions, and enhanced decision-making in engineering and manufacturing tasks [14].

In the field of robotics and artificial intelligence, the conversion of inanimate, artificially animated items into living things is an exciting challenge as well as a chance for creativity. However, effective and trustworthy procedures for overseeing this transition process are typically absent from current methodologies. One significant area of study still needs to be addressed: developing automated systems that can coordinate the sequential deployment of these creatures into assigned tanks within time limitations, resulting in the best possible transformation outcomes.

The proposed article delineates in this model this research gap by presenting an automated system that employs a robot crane to oversee the transformation process. This model addresses this research gap by presenting an automated system that employs a robot crane to oversee the transformation process. Predetermined time parameters are used to control each being of the system’s sequential placement of artificially animated entities into three different tanks. Owing to the overcooking of the creatures that occur from not meeting these time limitations, the transformation process must be executed with accuracy and efficiency.

The objective of this model is to address the current gap in automated transformation systems for artificial entities by presenting a systematic method that makes use of a robot crane and a statechart-based control system. This work aims to enhance the fields of artificial intelligence and robotics by integrating sophisticated robotics with intelligent control mechanisms to create more dependable and effective transformation processes.

2. Methodology

2.1. Overview

This section outlines the methodology employed in this study to sequence the placement of raw artificial animated beings into three different tanks. Each tank mandates that an artificially intelligent entity occupy it for a predetermined duration, falling within a specified minimum to maximum range. Should the maximum duration be exceeded, the artificial animated being is considered overdone and consequently disposed of. Conversely, if the duration falls within the specified range, the artificially generated entity transforms, becoming ‘alive’, and subsequently departs after completing the cycle through the third tank.

The AnyLogic environment was used to create the suggested simulation model. AnyLogic facilitates feedback system modeling and development. The AnyLogic model is intended to demonstrate an automated system that uses a robot crane to supervise the transformation procedure. The environment lets you modify the model’s parameters while it is running, which is comparable to human interaction in a variety of processes in real life.

2.2. AnyLogic Simulation Software

AnyLogic is a flexible simulation tool used in many different sectors to represent intricate systems and procedures. It enables users to create simulations by combining several modeling paradigms, such as a discrete events, agent-based, and system dynamics modeling. This adaptability makes it possible to model and analyze a wide range of systems, including supply chains, manufacturing, healthcare, and transportation.

The model is developed within the AnyLogic environment, utilizing a combination of agent-based and discrete-event approaches [15-21]. AnyLogic software holds significant importance in the Robotics and AI domain, offering a versatile platform for modeling, simulating, and optimizing complex systems. It enables the creation of detailed simulations for robotic systems, empowering engineers and researchers to simulate robot behavior across diverse scenarios [22, 23]. This capability is crucial for testing and validating algorithms, control strategies, and overall system performance in a virtual environment prior to physical implementation [15, 24-26].

The agent-based modeling capabilities of AnyLogic are instrumental for simulating intelligent agents in AI applications [16, 27-29]. AnyLogic provides a framework for simulating complex interactions and dynamics, whether it is for decision-making processes, smart sensor behavior modeling, or autonomous robot behavior modeling. Optimizing movement and task execution is critical in robotics [30-34]. AnyLogic enables the optimization of robot movements within specific environments. Through simulations, users can explore various algorithms and parameters to improve path planning, task allocation, and overall system efficiency [35-39].

AnyLogic is a simulation modeling software developed by the Russian company XJ Technologies. The name “AnyLogic” reflects its support for three well-known directions of simulation modeling approaches (as shown in Figure 1), allowing users to combine these methods within a single model.

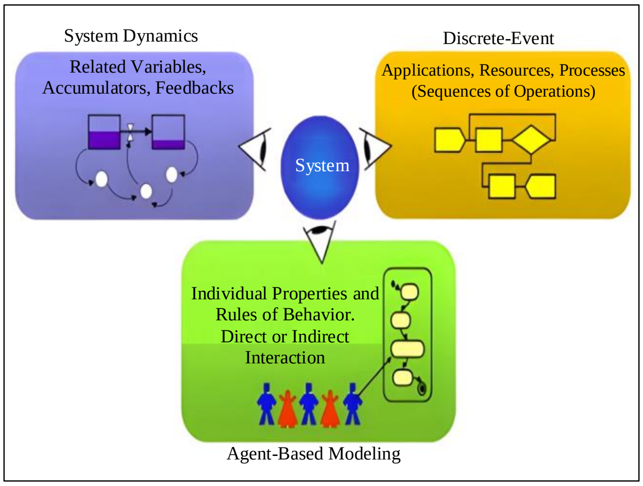


Fig. 1 Three simulation approaches supported by AnyLogic

The executable simulation models that are created with AnyLogic are then run for analysis. Model development is done in the AnyLogic graphical editor with the help of a number of helpful features that make the process go more smoothly. After that, the built-in AnyLogic compiler is used to compile and run the model. Users can conduct a variety of experiments with the model, observe its behavior, modify parameters, and view simulation results in multiple forms while the model is running. To specify the robotic duties, create the application interface, model, and simulate the system, AnyLogicTM was used. The discrete event, agent-based, and system dynamics simulation techniques were all used in the robotic system model simulation [40].

2.3. Robot Environment

The term “Robot Environment” refers to the surroundings within which a robot operates, comprising various elements and conditions that impact the robot’s behavior, performance, and interactions. In this study, a simulation model utilizing the robot was developed to position raw artificial moving objects within three distinct tanks within a designated environment.

Leveraging the AnyLogic enterprise library facilitates the rapid creation of complex models involving discrete events.

This environment consists of three tanks arranged in a specific configuration within a defined area. Additionally, the robot, which functions akin to a crane, is implemented as an agent equipped with four state charts: three governing the robot's three degrees of freedom and one serving as the higher-level controller, as shown in Figure 2.

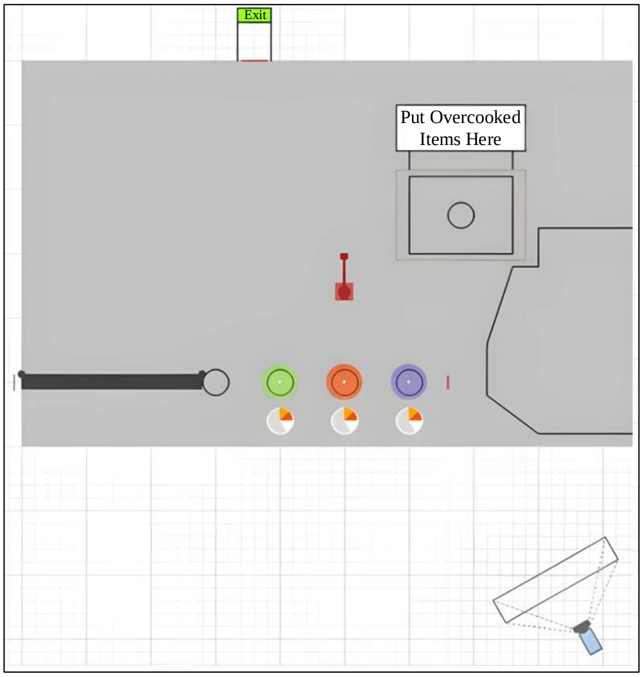


Fig. 2 Robot environment in a specific arrangement within a specific area

The model and animation are swiftly constructed in a drag-and-drop manner, offering flexible parameterization. Users have open access to implementing standard objects, with the option to expand their functionality as desired, including the creation of custom libraries. By utilizing hierarchy and regular object structures, scalable models can be developed.

The Enterprise Library object library enables the creation of adaptable models with a visual representation of the simulated process and the capability to gather essential statistics tailored to support discrete-event modeling.

The model, as depicted in the following figure, consists of three distinct tanks arranged within a specific area. Raw artificial animated beings are sequentially passed along the line, traversing through the three positioned tanks: green, red, and concluding at the blue tank.

- The position in the green tank is (300, 350, 0) with a rotation of -90 degrees.
- The position in the red tank is (350, 350, 0) with a rotation of 0 degrees.
- The position in the blue tank is (400, 350, 0) with a rotation of +90 degrees.

3. Implementation of the Simulation Model

By following the steps, one can effectively implement the simulation model in AnyLogic to simulate the movement of animatronics through the tanks as described.

3.1. Simulation Implementation

In the active object graphic editor window, a two-dimensional or three-dimensional animated representation is constructed for the model, aiding in comprehending the model's behavior over time. This window serves as the platform where the simulation of the system's behavior is visually depicted. Each element of the animation picture possesses its parameters, which can be linked to variables and parameters of the model. As model variables evolve, the graphical representation also changes accordingly, enabling users to visualize the dynamics of the simulated system through dynamically evolving graphics (refer to Figure 3).

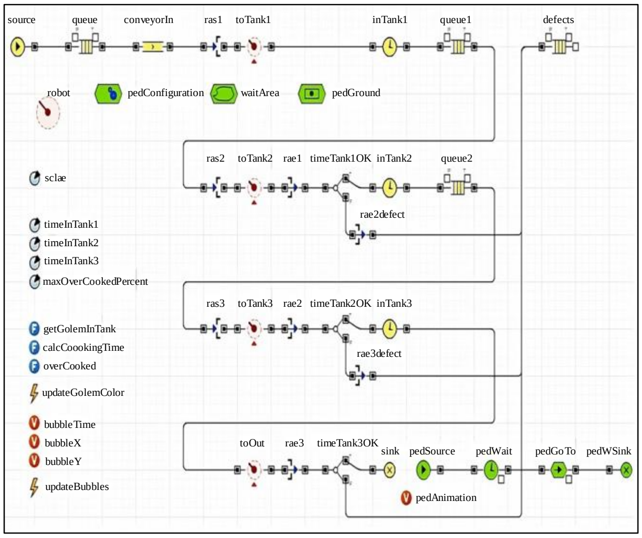


Fig. 3 Flow chart processes

The process flow chart commences with the modeling of the raw artificial animated being, which includes a source, queue, and a conveyor leading to the three tanks. Additionally, a timer is incorporated to track the duration of the organisms in the tanks. If the maximum time limit is exceeded, the artificial animated being is considered overcooked and disposed of. However, if the time limit is within the specified range, the artificial animated being transforms into a living state and departs after passing through the third tank.

The terms "Start Rotation" and "Finish Rotation" are commonly utilized in robotic motion planning, particularly in mobile robotics or industrial automation. These terms denote specific actions or states associated with the rotation of a robot as it transitions from one position to another. Figure 4 illustrates the diagram of the rotation and movement operations of robots.

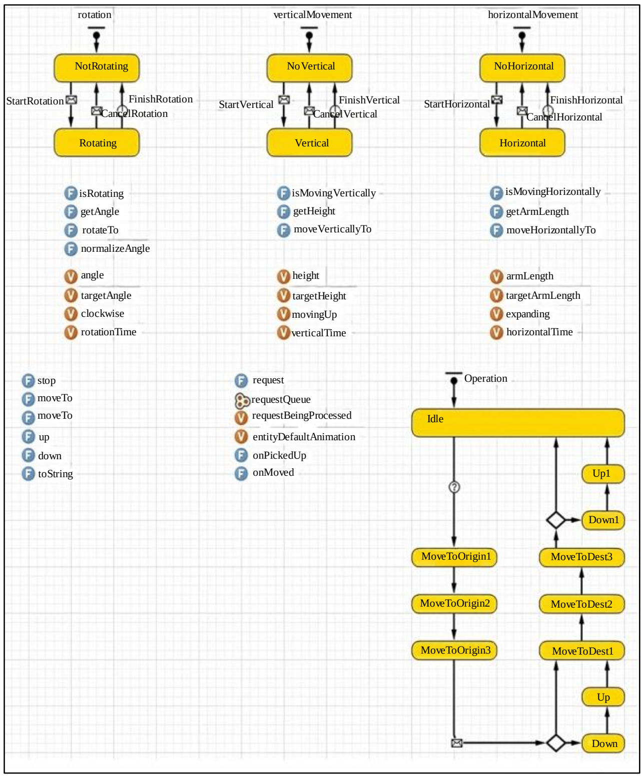


Fig. 4 Diagram of rotation and movement operations of robots

Start rotation refers to the initial phase of rotation that a robot undergoes when it begins to change its orientation. This occurs when the robot needs to reorient itself to align with a new direction or target as part of a movement sequence.

Finish rotation, on the other hand, indicates the completion of the rotation process. It signifies that the robot has successfully rotated to the desired orientation or angle, thus completing the reorientation process.

In practical terms, start and finish rotations are important components of path planning and motion control algorithms in robotics. These rotations need to be accurately calculated and executed to ensure that the robot moves smoothly and efficiently to its intended position and orientation. Various techniques such as kinematic modeling, sensor feedback, and control algorithms are employed to achieve precise start and finish rotations, depending on the specific application and requirements of the robot.

The vertical and horizontal movement of a robot refers to its ability to move along different axes in space. Horizontal Movement refers to the movement of a robot along the X and Y axes in a two-dimensional plane. Horizontal movement allows the robot to traverse a surface or workspace without changing its altitude. Vertical Movement refers to the movement of a robot along the Z-axis, typically involving changes in altitude or elevation. Vertical movement allows the robot to change its height or position relative to a reference point.

The operation of a robot's "up and down" movement, typically referred to as vertical movement, involves controlling its motion along the vertical axis, typically represented as the Z-axis in a three-dimensional Cartesian coordinate system. Meanwhile, "move" usually refers to the robot's horizontal movement along the X and/or Y axes. In summary, the operation of a robot's "up and down" movement involves controlling its vertical motion along the Z-axis. At the same time, "move" refers to its horizontal movement along the X and/or Y axes.

Utilizing a robot for tasks such as lifting, waiting, picking up, moving, and holding positions involves programming the robot's controller with specific instructions. By following these steps and programming the robot accordingly, you can effectively harness its capabilities for various applications (refer to Figure 5).

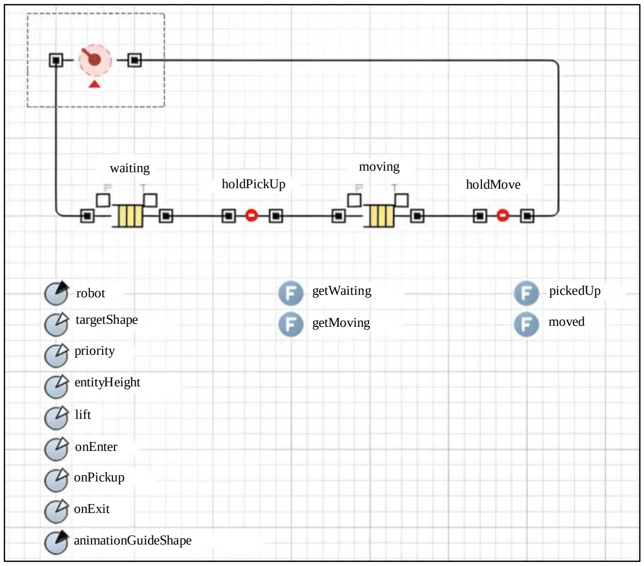


Fig. 5 Programming the robot control unit includes specific instructions

Determination of the conditions for waiting that indicate when the robot should enter a waiting state. This could be based on time intervals, sensor readings, external signals, or specific events. Determination of the object to be picked up by ensuring that the robot end-effector is equipped with the appropriate tools or handle to hold the object securely.

The destination is determined by the target location or path that the robot must follow to move the object. The movement path is programmed by specifying the sequence of movements required for the robot to move to a destination.

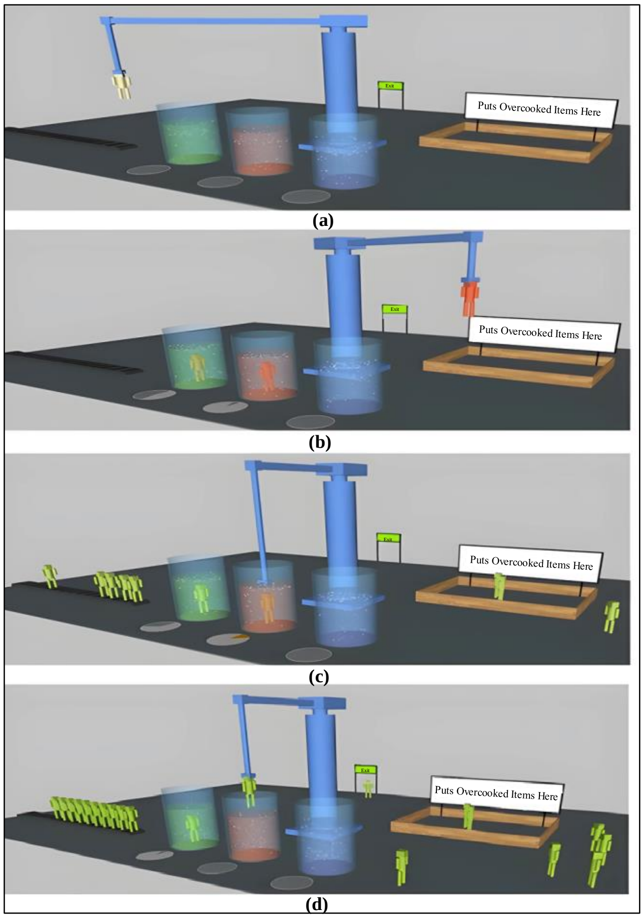
This may include planning a route, avoiding obstacles, and adjusting speed and acceleration to ensure safe and efficient movement. The movement is executed by sending commands to the robot controller to initiate the movement sequence.

Hold move typically refers to a state where the robot maintains a specific position while also being capable of responding to external stimuli or commands. Achieving a hold move state involves programming the robot's control system to continuously monitor its position and adjust its actions as needed to maintain stability and accuracy.

3.2. Experimental Results

In this section, the results are presented from the first step to several successive steps for each of the artificially animated beings. Figure 6 and its subfigures show a snapshot of the results in this task completion environment. The experiment parameters will be as follows:

- Scale = 50;
- Time in tank 1 = 5.5;
- Time in tank 2 = 6;
- Time in tank 3 = 6.5;
- Max Over Cooked Percent = 1.5.



(a)

(b)

(c)

(d)

Fig. 6 Experimental results steps

Subfigure (a) depicts the beginning of the process, where the first raw artificial animated being moves onto the platform and proceeds towards the three tanks. Each artificial animated being in the tanks must spend a certain amount of time between the minimum and maximum thresholds. In subfigure (b), the maximum time limit was exceeded for some of the artificial animated beings in the tanks, resulting in them being overcooked and discarded. Subfigure (c) illustrates a scenario where the maximum time limit was not exceeded for the third artificial animated being in the third tank. As a result, this artificial animated being completes the process and becomes 'alive', moving away from the tanks. Finally, in subfigure (d), the process is repeated for all remaining artificial animated beings, and they are sorted accordingly based on the outcome of the process.

These subfigures provide snapshots of different stages of the task completion environment, showcasing the progression of the process and the outcomes for each artificial animated being.

Figure 7 shows images of the output of artificial animated beings, using AnyLogic simulation software in a single Graphics Interchange Format (GIF) image in order to show and allow users or researchers to understand the output of this model in a real-life scenario.

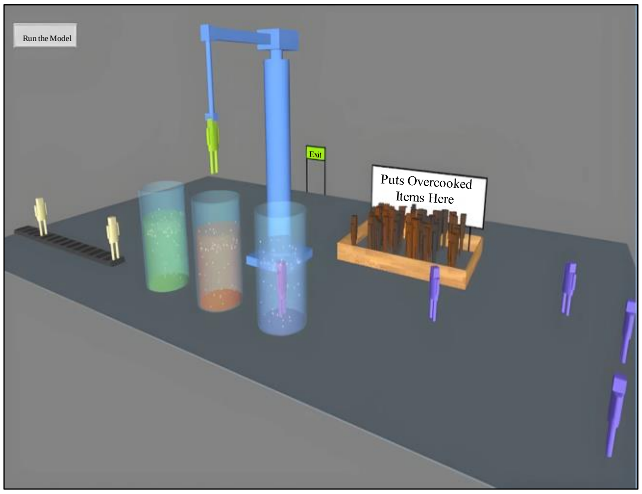


Fig. 7 Graphics Interchange Format (GIF) image of an artificial animated being, using AnyLogic simulation software

4. Conclusion

Indeed, robotic systems are undergoing rapid evolution at an unprecedented pace. While the ultimate objective of robotic systems is to deploy real-world robots, there is significant value in conducting simulations before actual deployment. Modeling and simulation of robotic applications provide a means to evaluate various designs and configurations of robotic systems before they are implemented in the physical world. This approach allows researchers, engineers, and developers to assess the performance, efficiency, and feasibility of different robotic system designs, enabling iterative improvements and optimizations prior to real-world deployment.

The centralized control system model is built using the AnyLogic environment, which supports all modern simulation modeling methodologies: system dynamics, discrete-event and agent-based modeling. AnyLogic provides the developer with the ability to use a unified language to create models, which simplifies the construction of agent-based models. The Unified Modeling Language supports state diagrams used to define agent behavior; transition diagrams intended to describe algorithms, environmental objects used to describe the environment of the existence of agents and collect statistics about their behavior; as well as mechanisms for describing random or timed events that determine the logic of the simulation.

In this model, a robot is utilized to sequentially place raw artificial animated beings into three distinct tanks following a specific order. Each artificial animated being must spend a designated period in each tank, falling within the predefined minimum and maximum durations. If the maximum time limit is exceeded, the artificial animated being is considered overcooked and discarded. Conversely, upon completing the cycle through the third tank, the artificial animated being transforms, becoming a living being and subsequently departs.

The robot, akin to a crane, is represented as an agent incorporating four state charts: three managing the degrees of freedom and one acting as the overarching controller. It offers two interfaces: an Application Programming Interface (API) featuring functions like moveTo(), stop(), etc., and flowchart objects named UseRobot, applicable within Enterprise Library flowcharts, as exemplified in this model.

It is clear from contrasting suggested research with existing findings that traditional approaches are insufficiently sophisticated and flexible to handle the intricate series of tasks needed in the transition of artificial beings. Although other studies have looked at automated systems for comparable goals, the suggested approach stands out for combining complex robotic manipulation methods with statechart-based control.

Additionally, the system provides flexibility and ease of integration into current frameworks by offering two unique interfaces: an Application Programming Interface (API) and flowchart objects compatible with Enterprise Library flowcharts.

In summary, the research signifies a noteworthy progression in the domains of robotics and artificial intelligence, providing a fresh approach to the problem of mechanizing the development of synthetically animated entities. The goal of the paper is to push the frontiers of what is feasible in artificial being manipulation and transformation by fusing cutting-edge technologies with creative control tactics. This will pave the way for more dependable and efficient transformation systems.

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