Rat Roulette

Olivia Mei
MEng in Computer Science
Cornell Tech, Cornell University
om228@cornell.edu

Julia Yu
MEng in Electrical and Computer Engineering
Cornell Tech, Cornell University
jy967@cornell.edu

Ann-Kareen Gedeus
PhD Student, Department of Information Science
Cornell University, Bowers College of CIS
ag2637@cornell.edu

Yuanchen Bai
PhD Student, Department of Information Science
Cornell University, Bowers College of CIS
yb299@cornell.edu

Abstract*—Our game, Rat Roulette, was designed to teach middle school students about probability through playing an interactive and simplified version of roulette. Players are presented with a roulette circle with 8 sections, alternating between red and black, and numbered 1 to 4. A robot will spin on this circle and players must guess where they think the robot will stop spinning at. Players make their predictions by either guessing the color or the number the robot will land on. If they guess the color correctly, they earn 1 cheese token; if they guess the number, they earn 2 tokens, reflecting the 50% chance of guessing the color and the 25% chance of guessing the number. The robot uses RGB camera sensor data to detect people standing in winning positions and timer data for navigation purposes. The robot interacts with the players through movement and speech by navigating to the winning players of each round using its motors and providing instructions to participants throughout the game through its speakers. We assess the players' perceptions of the robot at the end of the game using the RoSAS survey, which evaluates attributes correlating with warmth, competency, and discomfort on a 1-7 scale. Our findings showed that participants scored the robot high in attributes relating competency and low in discomfort, suggesting that the robot was well-received in terms of fostering positive engagement. These findings support the idea that designing robot interactions with a target audience in mind can enhance educational experiences. By integrating robotics into classroom learning, we can create interactive environments that foster engagement and practice understanding of concepts like probability.

I. Introduction

Rat Roulette is an interactive and simplified version of the classic roulette game, where participants try to guess the stopping position of a randomly spinning robot. Each spin generates a combination of color (red or black) and number (1 through 4), and the participant's task is to guess one of these attributes correctly. A correct guess of the color earns 1 point, while guessing the correct number awards 2 points. These points are tracked using 3D-printed cheese tokens, which are given to the participants at the end of each round. The objective of the game is to accumulate the highest number of points among all players.

For the embodiment of our robot, we chose a rat character, as seen in Figure 1. The inspiration for this design was drawn from the iconic rats often seen in New York City's subway stations. We wanted to create a playful, anthropomorphized rat robot to serve as the roulette dealer. The robot engages with the players through both movement and speech, moving to the winning players' positions and communicating how many pieces of cheese they should take from the robot's basket. It also uses speech to signal when to make a new guess and to announce the results of the spin.

The robot operates using a reactive control architecture that relies on timer data for navigation and RGB camera sensor data for human detection. This sensor data is processed and translated into commands for the robot's motors and speakers. Although we initially considered using a hybrid control architecture, which would involve navigating with a map (since the test bed layout is fixed), time and technical constraints led us to favor a fully reactive system due to its simplicity and reliability in various environments.

Our study aims to explore human perception of robots by having participants complete the Robotic Social Attributes Scale (RoSAS) after engaging with the robot during the game. Throughout the game session, the robot interacts with participants by approaching them when they win, speaking to them through its connected speakers, and having students take cheese tokens from the robot. Participants will then report how these interactions made them feel, based on both the robot's actions and its appearance, using the RoSAS survey. A demonstration of this process can be found in the following video: https://drive.google.com/file/d/1Bp0WgjKvbk7NIPJJ3mr5CZim9s4L3Rno/view?usp=sharing

II. Method

A. Game Design

This game, inspired by roulette, simplifies and adapts the traditional concept into a more interactive and engaging experience for players. The game area consists of a 6x10 feet game area featuring a central circle divided into 8 equal parts, representing a roulette wheel. Each section of the circle is labeled with a unique combination of a color (red or black) and a number (1, 2, 3, or 4), resulting in eight possible outcomes: R1, R2, R3, R4, B1, B2, B3, and B4. Surrounding the circle are 6 rectangles forming the betting layout, each labeled with

Fig. 1: Rat robot roulette dealer physical embodiment.

one of the six possible predictions: 1, 2, 3, 4, red, or black. Players place their bets by physically standing in the rectangle corresponding to their chosen prediction. 3D-printed cheese serves as the game's currency, held by the robot in a basket throughout the game.

The robot acts as both the dealer and the roulette ball, dynamically interacting with the players. At the start of each round, it spins in the center of the circle, mimicking the motion of a roulette ball. After spinning for a few seconds, it stops randomly, with its facing direction determining the winning combination. The robot announces the results through its speakers and moves to the corresponding winning rectangles—one for the color and one for the number—indicating the correct answers. It then instructs the winners to take the appropriate amount of cheese from its basket: 1 cheese for correctly guessing the color (a 50% probability) and 2 cheeses for correctly guessing the number (a 25% probability).

Players actively participate by making predictions at the beginning of each round, choosing a rectangle labeled with their guess and standing in it. Once the robot stops, players observe its movements and listen to its announcement to see if their predictions were correct. Winners then collect their cheese rewards, guided by the robot's instructions. The game continues for as many rounds as time permits, with players competing to accumulate the most cheese. At the end of the game, the player with the most pieces of cheese is the winner.

B. Finite State Machine (FSM)

The finite state machine for our game begins in the Start state, where the robot is positioned at the center of the roulette circle. In this state, the robot waits for the RGB camera, used for MobileNet detection, to activate. Once active, the robot plays the "Start" audio clip and transitions to the Spin state. In the Spin state, the robot randomly selects an answer and spins for a predefined duration before stopping at the corresponding section of the roulette wheel. After stopping, the robot transitions to the Announce Result state, where it reports the correct answer through its speaker.

When the announcement audio finishes, the robot enters the Navigate state, moving toward the rectangle corresponding to the correct color. It adjusts its linear and angular velocities based on a timer to reach the designated position. Upon arrival, the robot transitions to the Detect state, using the RGB camera to check if a participant is standing in the correct rectangle. If a person is detected, the robot proceeds to the Reward state, where it congratulates the participant and offers them the 3D-printed cheese. If no person is detected, the robot plays a "losing" audio clip and transitions back to the Navigate state.

After completing the Reward state for the color guess, the robot loops back to the Navigate state to move toward the rectangle corresponding to the correct number. The Detect and Reward processes repeat for this second answer. Once both correct answers have been addressed, the robot transitions to the Reset state, where it uses timers to return to the center of the roulette circle. Upon reaching the center, the robot transitions back to the Start state, and the process repeats for the next round.

Current State	Input	Next State	Output
Start	Camera active and start audio finishes	Spin	Set angular velocity to rotate
Spin	Time elapsed for n seconds	Announce Result	Set the angular velocity to 0 (stop rotating)
Announce Result	Audio playing completed	Navigate	Set linear velocity to move forward
Navigate	Reached box for correct guess	Detect	Set linear and angular velocity to 0
Detect	Person Detected (using MobileNet from Camera)	Reward	Results audio plays
Detect	No Person Detected and correct results remaining	Navigate	Set linear velocity to move forward (to next correct box)
Detect	No Person Detected and no correct results remaining	Reset	Set linear and angular velocity to some non-zero value
Reward	5 seconds elapsed and 1 result left	Navigate	Success audio plays and set linear/angular velocity
Reward	5 seconds elapsed and no correct results remaining	Reset	Success audio plays and set linear/angular velocity
Reset	Time elapsed for robot to navigate to center	Start	Set linear and angular velocity to 0

TABLE I: State transitions and outputs for the finite state machine

C. Robot Control Architecture

Our team opted for a reactive robot control architecture, where no long-term planning is employed. Instead, the robot's behavior relies on immediate responses to specific triggers, such as timers and sensor data. Initially, we considered a hybrid control architecture, which incorporates elements of

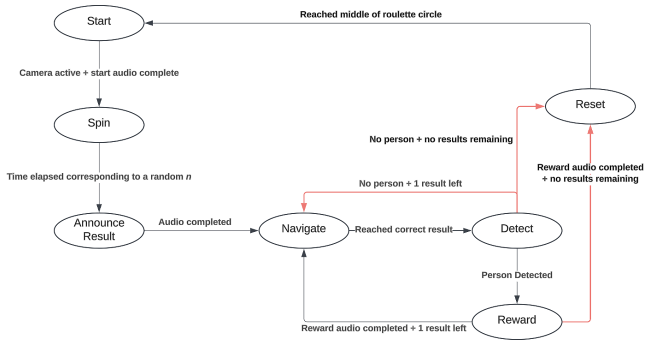

Fig. 2: Illustration of the finite state machine

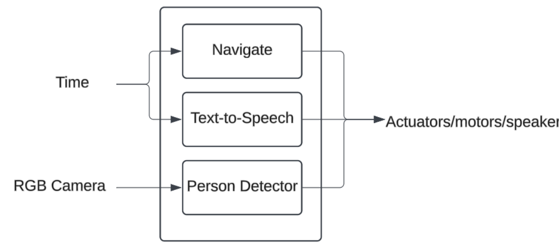

Fig. 3: Rat Roulette's reactive robot control architecture.

both planning and reaction. However, we found that relying on a map resulted in inconsistent outcomes across multiple trials, even with identical code.

The system was implemented and tested on the TurtleBot4 platform, with the complete implementation available in our GitHub repository(https://github.com/olivesmoo/rat-roulette) . Users can deploy the system using the roulette_launch file, which simultaneously activates the Rat Roulette node and the MobileNet Detection module.

This architecture employs both sensor data and timers as inputs. Specifically, the Rat Roulette node subscribes to a MobileNet detection publisher to process RGB camera data for object detection and classification. The received data, in the form of a Detection2DArray, specifies both the classification of detected objects and their positions within the camera's view. To verify if a person is standing in the correct position, the system checks for the presence of a person in the middle of the camera's field of view, ensuring precise alignment. Timers play a critical role in regulating the robot's actions when not actively sensing the environment. They are used for various game components, including determining the duration of the robot's spin on the roulette circle, managing navigation to designated positions, and setting time limits for person detection.

In terms of outputs, the Rat Roulette node publishes commands to the cmd_vel topic to control the robot's motors, enabling it to spin on the roulette circle and navigate to the correct positions. The system also utilizes speakers to communicate with players and guide gameplay. The robot provides verbal instructions for making predictions, announces the correct results, congratulates and rewards winners if detected by the camera, and plays a losing sound effect if no person is detected in the winning position.

The system operates primarily in a sequential manner, where specific actions are triggered only after certain inputs are detected or previous outputs are completed. For instance, person detection does not begin until the robot has reached its destination and stopped, and text-to-speech instructions are delivered only after the time allocated for person detection has elapsed. The only parallel process involves the robot playing sound effects while simultaneously spinning on the roulette circle.

D. Robot Design and Prototyping

To prototype the robot, we utilized both paper prototyping and sketching. As shown in Figure 4, the paper prototype was constructed using materials such as paper, straws, and wooden skewers. This half-foot-tall miniature model enabled us to cheaply and effectively visualize our embodiment concept without significant risk or commitment. In this version, we designed a simple rat form, with a phone display intended to represent the face of the robot.

Building on ideas from the initial prototype, we refined the thematic design of the rat. Figure 5 illustrates a sketch of the revised embodiment, where the robot was reimagined as a roulette dealer. This updated design depicts a rat dressed in a suit and holding a basket, aligning more closely with the intended final embodiment.

To bring the physical embodiment to life, we employed various fabrication methods tailored to the requirements of each component:

a) 2D Laser Cutting: Laser cutting was used to shape the internal structure, arms, and basket. These parts were cut from wood to ensure durability and structural stability. The laser-cut designs are shown in Figures 6 and 7.

b) 3D Printing: 3D printing was used for the robot's body parts, including the head, hands, and feet, as well as smaller details such as the cheese currency, suit buttons, and the camera holder rat. Most of the 3D models were sourced from online repositories like Thingiverse and were customized to meet our design specifications. We selected 3D printing for these components due to the precise details and organic forms required. Examples of the printed parts are shown in Figure 8.

c) Painting and Finishing: To achieve the desired color, many 3D-printed pieces were finished using spray paint, sanding paper, and acrylic paint. This step was necessary as suitable filament colors were unavailable during fabrication.

d) Clothing Fabrication: The robot's outfit was hand-crafted from cloth and assembled using hot glue to enhance its realism and align with the roulette dealer theme.

e) Vinyl Cutting: The roulette circle was crafted from vinyl, with each section individually cut and pasted onto a thin cardboard base. We chose to use vinyl due to its durability

Fig. 4: Paper prototype of rat robot.

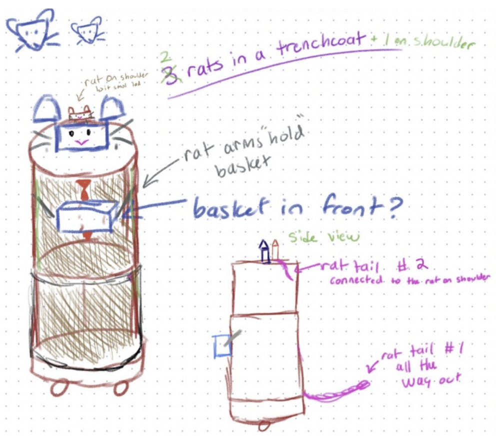

Fig. 5: Revised sketch of the rat robot.

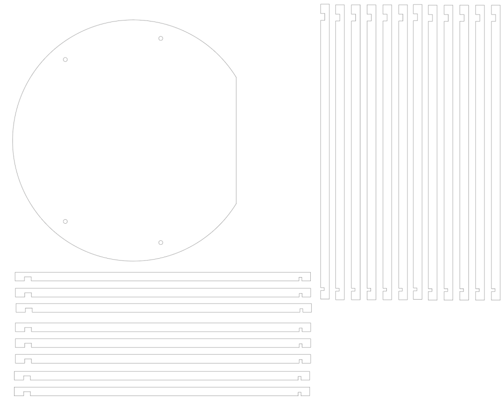

Fig. 6: Laser cutting file for the robot body structure.

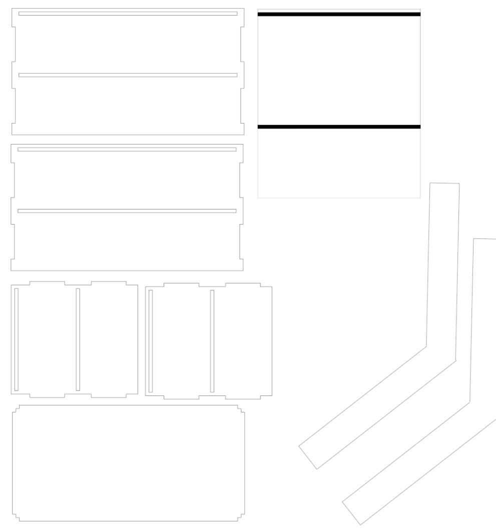

Fig. 7: Laser cutting file for the basket and arms.

and ability to withstand foot traffic, making the roulette circle more robust compared to paper-based materials.

III. Procedure

A. Participants

Our participants were students aged 12 to 14, recruited during a field study at a public event where they rotated through various robot exhibits. A total of 17 students participated in our game, organized into four groups. We employed a convenience sampling approach, with participation determined by the students' availability and interest.

B. User Studies

The study began with a warm welcome and an introduction to the game rules. We answered any questions the participants had to ensure clarity. Following this, the gameplay started. The game consisted of multiple turns, with the exact number determined by time availability, generally around four rounds. During each round, every student chose a spot to stand on. Afterward, the robot made its choice and approached a student standing on a selected spot, prompting them to take the "cheese" (the reward for being the winner), as described in the Method section. Once all the turns were completed, participants returned the rewards they had collected. As a token of appreciation, each student received a cheese-shaped keychain as a keepsake. Finally, we distributed the RoSAS survey for each of the participants to complete. After they finished, we collected the surveys.

The game was set up within a designated 10' x 10' demo area in a large indoor space. The active gameplay zone was marked as a 6' x 10' area at the edge of the demo space using black masking tape. A 5' x 18" table occupied the

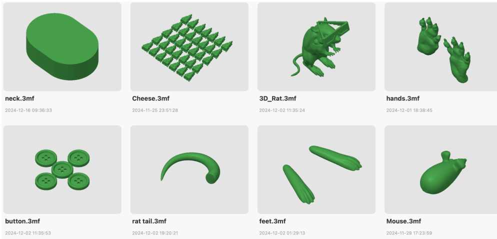

Fig. 8: 3D models printed for the robot embodiment.

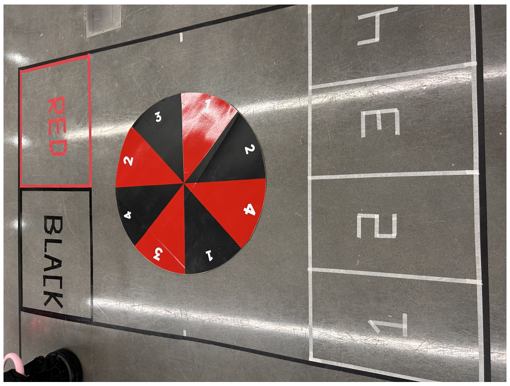

Fig. 9: User study gameplay area for Rat Roulette.

remaining space to hold additional materials. At the center of the gameplay area, the circular roulette plate was placed, with the robot positioned at its center. To provide clear visual guidance for participants, grids were outlined on the floor using colored tape and labeled with the indicators [RED], [BLACK], [1], [2], [3], and [4]. The [RED] and [BLACK] indicators were placed on one side of the roulette plate, while the numbers [1], [2], [3], and [4] were positioned on the other side, as illustrated in Figure 9. The colored rectangles measured 2.5’ x 3’, and the numbered sections measured 2.5’ x 1.5’ each.

In preparation for the study, we conducted multiple rounds of private testing to verify the game’s functionality. The setup was simulated in an empty classroom space and tested two days prior to the public demonstration, as shown in Figure **??**. On the evening before the event, we finalized the setup in the designated demo space. A final round of testing was conducted on the morning of the event to ensure that all components were functioning properly, as seen in Figure 11. During these rounds of testing, we wanted to check that the taped gameplay area was accurate and consistent with the layout programmed into the robot, as the navigation relied heavily on timer-based movement. Additionally, we verified that the robot’s audio clips were clear, audible, and played as intended to provide a smooth participant experience.

C. Evaluation Metrics

The self-report measure used in our study was the Robot Social Attribute Scale (RoSAS), a tool designed to assess human perceptions of a robot’s social qualities. RoSAS evaluates 18 attributes across three dimensions: warmth (feeling, happy, organic, compassionate, social, emotional), competence (knowledgeable, interactive, responsive, capable, competent, reliable), and discomfort (aggressive, awful, scary, awkward, dangerous, strange). These attributes provide a detailed understanding of participants’ impressions of the robot’s emotional, interactive, and mechanical nature, offering insight into its social perception.

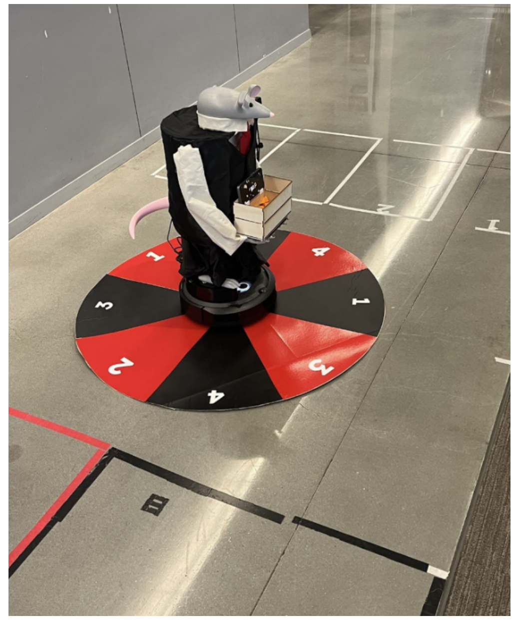

Fig. 10: Rat Roulette’s setup in the simulated test.

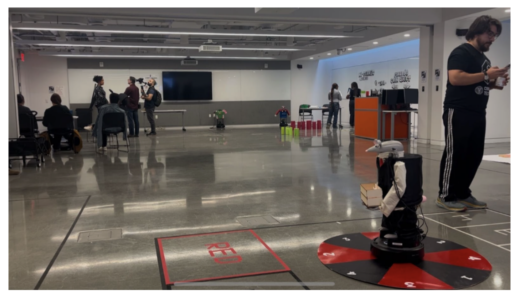

Fig. 11: Rat Roulette’s Setup On the Public Event Day.

D. Results

In this section we discuss our results for the descriptive statistics for participants (n = 17) on the Robot’s Social Attribute Scale (RoSAS). The scores reflect participants’ social perceptions of our robot as they interacted with it during our game. The highest-rated average score of 5.588 was for the attribute “Interactive” indicating high-levels of engagement, while the lowest-rated average score of 1.411 was for the attribute “Aggressive” indicating low perception levels of aggressiveness with the robot.

The averages for the remaining attributes are as follows: “Dangerous” (AVG = 1.47); “Awkward” (AVG = 1.941); “Feeling” (AVG = 4.529); “Strange” (AVG = 2.529); “Knowledgeable” (AVG = 4.529); “Reliable” (AVG = 5.294); “Happy”

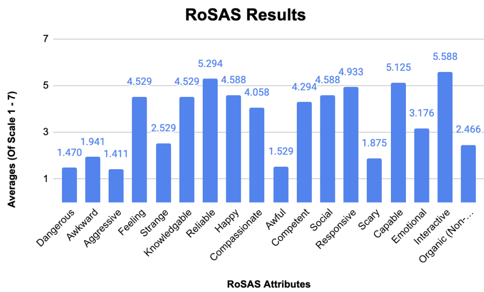

Fig. 12: Average score for each RoSAS attribute.

(AVG = 4.588); “Compassionate” (AVG = 4.058); “Awful” (AVG = 1.529); “Competent” (AVG = 4.294); “Social” (AVG = 4.588); “Responsive” (AVG = 4.933); “Scary” (AVG = 1.875); “Capable” (AVG = 5.125); “Emotional” (AVG = 3.176); and “Organic (non-mechanical)” (AVG = 2.466). The results are further visualized in the Figure 12.

E. Conclusion

Upon reviewing our results, we observed a clear distinction between the attributes associated with discomfort and those related to competence. The discomfort-related attributes, including ”aggressive,” ”awful,” ”scary,” ”awkward,” ”dangerous,” and ”strange,” generally received low ratings, with ”strange” having the highest average score of 2.5, while the others fell below 2. In contrast, the attributes reflecting competence—such as ”knowledgeable,” ”interactive,” ”responsive,” ”capable,” ”competent,” and ”reliable”—were rated much higher, with the lowest-rated attribute, ”competent,” still averaging around 4.3. This comparison highlights that the social perception of our robot was largely positive, with participants perceiving it as capable rather than uncomfortable. In addition, when examining the warmth-related attributes, many of them had high average scores. Specifically, we found that ”feeling,” ”happy,” ”compassionate,” and ”social” all had averages surpassing 4. This suggests that participants felt, in many aspects, a positive emotional connection during their interaction with the robot.

Another interesting finding was that none of the attributes scored above 5.6, indicating that participants did not express extreme opinions about the robot. This suggests that while the robot was generally well-received, participants maintained a balanced view, without strongly positive or negative feelings about the robot’s characteristics as measured by the RoSAS.

Several technical issues arose during the study, including the need for manual adjustment of the robot’s position after each round and occasional failures in the camera’s player detection. The manual adjustments were necessary because the robot’s preprogrammed movement timing did not always align with its intended destination, often due to inaccuracies in its starting position or misalignment in its orientation. Additionally, the camera issue appeared to be related to its technical limitations, where it sometimes failed to detect objects or struggled to accurately identify a player when they were positioned too close to the camera.

For future iterations, we suggest incorporating Simultaneous Localization and Mapping (SLAM) to create a map-based navigation system rather than relying on hardcoded movement timings. This would allow the robot to use waypoints to navigate to specific locations, such as the token-awarding spots and the center of the wheel. However, this approach would face challenges due to the game’s transportability, as the setup is temporary and marked with masking tape. The only consistent components are the roulette wheel and the robot itself.

This study provided valuable insights into the design of a robot’s actions and physical embodiment. We learned that even small details, such as movement and appearance, greatly influence how users perceive the robot. For future work, it would be interesting to explore how robots should be designed for different audience groups, such as children or elderly individuals. Each group likely has distinct needs and preferences, and understanding these differences will help tailor the robot’s design to ensure it fosters positive interactions for its intended users.