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ROBOTIC PROCESS AUTOMATION MEETS CLOUD COMPUTING: A FRAMEWORK FOR AUTOMATED SCHEDULING IN SOCIAL ROBOTS

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ABSTRACT

The investigation offers a new approach that combines robotic process automation (RPA) with cloud computing to increase the utility of social robots, particularly for older people and people with cognitive impairments. The proposed system utilises cloud computing's massive processing power and enables responsive user engagement, efficient work scheduling, and real-time object and behaviour recognition. Critical components such as the Behavior Recognition Engine (BRE), Object Recognition Engine (ORE), and Semantic Localization System (SLS) are optimised through the use of powerful deep learning models that are deployed on the cloud. These modules enable the robot to travel, do tasks, and interact with users dependably and accurately. In addition to showing significant improvements in overall system performance, including a 97.3% accuracy rate, the inquiry addresses deployment challenges and the need for consistent online connectivity. With cloud computing and RPA integration, this framework—a significant breakthrough in assistive technology—provides a workable solution to boost caregiver support and user independence.

KEYWORDS: *Robotic Process Automation, Cloud Computing, Social Robots, Object Recognition, Behavior Recognition.*

INTRODUCTION

Technology has evolved significantly in the last several years, especially in fields like cloud computing and robotic process automation (RPA). These advances have started to cross in fascinating ways, particularly in assistive robots. The investigation aims to offer a framework that leverages the advantages of cloud computing and robotic process automation to develop an automated scheduling system for social robots that will benefit older people and those with cognitive disabilities. Utilising the cloud's capacity, these robots can monitor work completion, manage daily routines, and engage with users more responsively and dynamically. Compatibility between cloud technologies and RPA is the foundation of this system. Social robots can perform ordinary chores more efficiently when RPA combines the cloud's infinite resources. Integrations like this are beneficial when robots perform computationally demanding real-time tasks like object and behaviour recognition. Because these operations can be carried out swiftly and precisely thanks to the cloud, users can navigate their daily routines more effectively, with the robot guiding them through chores and offering feedback as needed.

The object recognition engine (ORE), which runs in the cloud, is the heart of this system. An essential part of the robot's ability to recognise different items in its surroundings is the ORE. Because it is based on a deep learning model optimised for cloud deployment, it can analyse large volumes of data and achieve high object detection accuracy. This feature is particularly crucial when the robot assists humans with tasks like finding a remote control or getting a glass of water that needs them to interact with various objects. The ORE can perform these tasks even under challenging surroundings with a lot of background noise or changing lighting conditions since it uses cloud resources. The framework incorporates a cloud-based behaviour recognition engine (BRE) and object recognition. The BREs are responsible for watching and comprehending human actions in various settings so that the robot can provide relevant assistance. For example, the BRE can determine if a user is correctly performing a task—like pouring a drink or cleaning their teeth. The system can gently correct the user anytime it detects a mistake, ensuring the work is finished correctly. This functionality is essential to preserve the user's independence and lessen the need for continual human monitoring.

Effective data management and analysis are among the main benefits of combining RPA and cloud computing. Data from several robots can be gathered, evaluated, and utilised to enhance the system, thanks to the cloud, which serves as a reference point. For instance, the ORE and BRE data can be uploaded to the cloud, which is utilised to constantly improve the deep learning models, thereby increasing their accuracy and flexibility. The robots' continual learning process improves their performance, improving the system's dependability in practical settings. The framework also includes a semantic localisation system (SLS) that uses cloud computing to improve the robot's navigation and environment comprehension. The SLS generates an intricate map of the surroundings by fusing cutting-edge visual recognition technology with conventional mapping methods. This map directs the user to the appropriate location for each activity and aids the robot's navigation through various rooms. The SLS can process massive volumes of visual data rapidly thanks to cloud computing, allowing the robot to adjust to environmental changes like new furniture or altered lighting.

The motion planning system (MPS), which determines the optimal routes for the robot to follow while moving, is another essential component of the system. The MPS and SLS collaborate closely to find the best route to the destination based on the location data provided by the SLS. The method ensures the robot can navigate complex surroundings without getting lost by combining local processing on the robot with cloud-based algorithms. This method offers a robust solution for real-time navigation and job completion using cloud and on-device computing advantages. The framework additionally incorporates speech recognition functionality to facilitate user interaction with the robot. This capability, powered by cloud services, makes communication easier by enabling the robot to comprehend and react to spoken commands. This is quite beneficial for those who might find it challenging to utilise a touchscreen or other physical interfaces. The speech recognition system can accurately handle complicated spoken commands even in noisy situations because of cloud computing. In real terms, users and providers stand to gain a great deal from applying this cloud-based RPA framework on social robots. The device gives users more independence by automating repetitive tasks and providing round-the-clock assistance. The system may be adjusted to match the unique requirements of each user by customising the timetable, which guarantees they receive the appropriate amount of assistance without feeling overburdened. The technology gives caretakers a dependable means of keeping an eye on and helping users from a distance, eliminating the need for continual in-person attendance and freeing caregivers to work on other urgent duties.

Numerous scenarios in which the system is being tested demonstrate its effectiveness, particularly when users require assistance with daily tasks. The robot can successfully perform its functions thanks to its excellent navigation, localisation abilities, and ability to distinguish objects and behaviours accurately. This achievement is mainly due to the utilisation of cloud resources, which offer the processing capacity and adaptability required to manage challenging jobs in real time. The system still carries several drawbacks. It takes a lot of knowledge and resources to set up, including mapping the surroundings and training the deep learning models. Furthermore, a steady and dependable internet connection is required for the system to function optimally because it depends on cloud computing. These considerations must be considered when deploying the system, particularly where users may not have access to technical help or where connectivity is limited.

- Develop a system that combines cloud computing and robotic process automation (RPA) seamlessly to build a sophisticated task management and scheduling framework for social robots.
- Improve Object and Behavior Recognition: Use potent cloud-based deep learning models to enhance the precision and velocity of object and behaviour recognition in social robots.
- Improve User Independence: Provide a system that enables social robots to assist older and cognitively challenged users in carrying out daily tasks with a higher degree of independence.
- Improve Data Processing: Use cloud resources to manage and analyse real-time data. This will help the system more successfully adjust to new tasks and situations.
- Improve Navigational Capabilities: Implement a system combining classical mapping and semantic localisation to ensure robots can consistently navigate complex and changing settings.
- Enhance User Interaction: Cloud-based speech recognition enables voice commands that allow users to comfortably and naturally engage with social robots.

While robotics uses cloud computing and RPA individually, few integrated frameworks combine these technologies to improve helpful robot capabilities. Current systems frequently fail in real-time task automation, environment adaptation, and user-friendly interactions. A cohesive strategy is required to effectively serve users in real-world scenarios by utilising the accuracy of RPA and the scalability of the cloud.

The need for assistive technology is increasing, particularly for older people and people with cognitive impairments, yet the efficiency, flexibility, and usability of current robotic systems are lacking. Frequently, these technologies cannot manage tasks in real time or offer the organic engagement that users require. By creating a framework that unites cloud computing and robotic process automation, this research seeks to address these problems by empowering social robots to automate scheduling, improve user independence, and improve task execution in intricate, dynamic contexts.

LITERATURE SURVEY

An in-depth analysis of how robotic process automation (RPA) is being applied to reshape the corporate landscape is provided by Devarajan's (2018) work. The report focuses on how RPA reduces costs, increases productivity, and simplifies manufacturing, healthcare, and finance activities. It also discusses the necessity for specialisedlabour and integrating RPA with current systems. In the future, the study contends that RPA's true potential will be revealed by its combination with AI and machine learning, which may result in more sophisticated and intelligent automation that will spur innovation and provide companies with a competitive edge.

Rosa (2016) delves into the notion of Cloud Robotics, an approach that enhances system performance and scalability by merging cloud computing and distributed robotics. Robotic systems may share data and access strong computing resources through cloud platforms, which improves their capabilities and allows for real-time collaboration. The study examines a number of applications, such as collaborative activities and remote robot management, and it also addresses constraints including latency, data security, and integration problems. All in all, it demonstrates how Cloud Robotics may revolutionize robotic systems by increasing their efficiency and flexibility.

Robotic process automation (RPA) is introduced in a straightforward manner in Primer (2015), and it also covers its advantages as well as ways to use it. The article defines RPA, describes its operation, and highlights some of its main benefits, including increased productivity, decreased errors, and cheaper expenses. It also provides helpful guidance on using RPA, such as how to select the best procedures and successfully incorporate the technology. It also provides examples from a range of sectors to demonstrate the practical applications of RPA.

Carden et al. (2019) examine the application of robotic process automation (RPA) at TECHSERV, emphasising the difficulties and achievements faced. The case analysis demonstrates that TECHSERV increased productivity, accuracy, and cost savings by using RPA to automate repetitive administrative operations. To guarantee a seamless deployment, the report emphasises the significance of meticulous planning, which includes getting cooperation from stakeholders and educating employees. TECHSERV eventually experienced streamlined processes, fewer errors, and increased staff productivity due to the RPA implementation, despite early hurdles like system integration and the requirement for ongoing monitoring. This case study provides valuable information for other companies considering RPA adoption to enhance their business procedures.

Ogle and Lamb (2019) examine ways service automation, robots, and artificial intelligence (AI) are transforming the events sector. They describe ways these technological advancements are combined to boost visitor experiences and event management. Examples of how robots and AI simplify duties like guest service, registration, and information distribution are given in the article. The advantages of these technologies—such as enhanced efficiency and personalized experiences—as well as their drawbacks—such as integration issues and adoption barriers—are also covered. In summary, the paper provides an in-depth analysis of how technology is changing the way people attend and interact with events.

Robotic process automation (RPA) is transforming the IT function; Willcocks et al. (2015) examine this. They talk about the way ordinary jobs can be automated using RPA to increase accuracy and efficiency while cutting expenses. In this document, successful RPA implementation tactics are outlined, including selecting the appropriate processes and handling organizational change. It also looks at the wider effects of RPA on IT departments, such as changes to roles and duties. Overall, the study offers a thorough analysis of how RPA is improving efficiency and changing IT operations.

Quality of Service (QoS) is the main emphasis of Chen et al. (2018) investigation into managing robotic streaming workflows in cloud robotics systems. They go over strategies for efficiently meeting QoS criteria while maximizing performance and resource usage. In order to improve service quality, the investigation discusses load balancing and dynamic scheduling techniques. In order to increase the efficacy and efficiency of cloud-based robotics systems, it also contains practical case studies that illustrate the way these methods might be used.

Eisanen (2019) investigates the ways that intelligent automation and robotic process automation (RPA) might improve public sector procurement procedures. The integration of these technologies to enhance productivity, accuracy, and cost-effectiveness is covered in the text. It describes how to apply intelligent automation and RPA through process transformation and stakeholder engagement. Along with demonstrating that these technologies can be effectively used in public sector procurement, the piece also provides practical examples that emphasize the potential advantages of combining intelligent automation and robotic process automation (RPA).

An extensive overview of behavioural models utilised in social robots is given by Nocentini et al. (2019), who also look at how these models facilitate social robot interactions with people. The investigation examines several methods—from straightforward rule-based systems to sophisticated machine learning—and weighs the benefits and drawbacks of each. It discusses that these models enable robots to interact with people, detect and react to emotions, and behave appropriately in social settings. The writers also highlight difficulties in adjusting to personal preferences and cultural differences. The survey highlights the necessity for continued research in this area and stresses the significance of creating adaptable models to enhance social robots' efficacy in real-world interactions.

A three-layer planning architecture is put forth by González et al. (2017) to use social robots in the autonomous management of rehabilitation treatments. Through the integration of behaviour generation, long-term planning, and real-time execution, the architecture is intended to personalise therapy. The top layer customises therapy plans for each patient, the middle layer creates behaviours corresponding to these plans, and the bottom layer ensures real-time adaptation depending on the patient's reactions. Enhancing patient participation and improving therapy outcomes are the goals of this method. Its adaptable architecture makes it a promising tool for individualised treatment with social robots, enabling it to meet various rehabilitation needs.

Geoffrey, an automated scheduling system for social robots intended to support people with intellectual disability, is introduced by Cruz et al.(2018). The system's interactive and helpful features assist users in managing their everyday jobs and activities. The design of Geoffrey, that emphasizes usability and accessibility, is highlighted in the essay. It also discusses the system's efficacy in light of user comments and performance reviews, demonstrating that it improves task management and encourages increased user autonomy.

With an emphasis on PwC Finland's experiences, Lindholm (2019) examines the shift in robotic process automation (RPA) from a project-based methodology to a service-oriented strategy. The subject matter looks at how PwC Finland's RPA efforts have developed from one-off projects to a full-service solution. The difficulties encountered during this shift, the advantages of a service-based model—such as enhanced scalability and ongoing support—and the methods employed to get around implementation roadblocks are some of the important points to note. The report offers a thorough examination of best practices and lessons discovered in growing RPA solutions, as well as insights into how PwC Finland oversees and maintains its RPA services.

INTEGRATED CLOUD AND RPA FRAMEWORK FOR ENHANCING SOCIAL ROBOTS METHODOLOGY

To make this framework a reality, the approach combines cutting-edge technologies into a single, cohesive system, including Robotic Process Automation (RPA), Cloud Computing, Speech Recognition, Object Recognition, and Behavior Recognition. The following part describes the system's primary parts and how they interact to provide the desired results. The system aims to improve social robots' abilities, making daily chores more accessible for older people and others with cognitive disabilities. Its primary goal is to automate the planning and completion of these actions so that users can promptly get the help they need. The system can handle complex jobs well by utilising cloud-based resources, allowing the robot to respond quickly and highly customisable to the user's needs. This system's core is automation, which relieves users who might have trouble remembering or planning their daily tasks. The system may manage and complete tasks by specified workflows through Robotic Process Automation (RPA), adjusting to user interactions and environmental changes. This flexibility is essential for giving each user individualised support corresponding to their unique needs.

Several essential modules that make up the system cooperate to provide a fluid and easy-to-use user experience. The Object Recognition Engine (ORE), one of the main modules, allows the robot to recognise and communicate with different items in the user's environment. The robot's cameras record visual data, which the ORE processes using sophisticated deep learning algorithms housed on cloud infrastructure. This enables the robot to accurately identify items in less-than-ideal environments like dimly lit or congested areas. This feature is especially crucial once the robot assists a user in finding particular objects, such as a remote control or a glass of water. The Behavior Recognition Engine (BRE), which watches and analyses user actions to ensure activities are completed correctly, is another crucial system component. Due to cloud computing, this module processes data in real-time, enabling the robot to intervene and assist the user if they need it. The BRE, for instance, may detect if a user is pouring a drink or brushing their teeth correctly. The system can help the user do a task effectively by giving prompt feedback or support if it senses something is amiss.

Table 1: Object Recognition Accuracy per Class

Object	Training Accuracy (%)	Validation Accuracy (%)	Test Accuracy (%)
Glass	93.4	92.8	94.3
Remote Control	91.2	90.5	92.7
Medication	94.1	93.6	95.2
Toothbrush	89.8	89.3	90.1
Bottle	95.6	94.8	96.3

Tab 1 displays the accuracy of the Object Recognition Engine at each stage—training, validation, and testing—to ensure dependable performance throughout tasks. It demonstrates how well the system can identify and categorise objects like glass, remote control, and medication within the robot's environment.

The system also features a Speech Recognition Module that enables humans and robots to communicate naturally. This is crucial for people who might find it challenging to operate physical controls. Thanks to cloud-based speech recognition services, the system can accurately interpret and respond to voice commands even in noisy situations. This improves the overall user experience by making interfacing with the robot simple and quiet. Motion Planning and Semantic Localization further enhance the system's functionality. The Semantic Localization System (SLS) builds a comprehensive map of the environment using visual input to assist the robot in comprehending its location within the house. The Motion Planning System (MPS) determines the robot's optimal routes as it moves from one location to another. These modules guarantee the robot can move around various areas quickly, assisting the user and completing chores properly. The Object Recognition Engine (ORE) is a crucial system component that enables social robots to recognise and interact with items in their surroundings. This module is essential for helping the robot identify a range of objects—especially when helping older people or people with cognitive impairments—because it leverages the power of cloud computing to tackle complex image-processing tasks.

The InceptionResNetV2 deep learning architecture, known for its excellent picture classification accuracy, is the ORE's foundation. The capabilities of two potent models are combined in this architecture: ResNet, which employs residual connections to sustain the performance of deep networks, and Inception, which captures a wide range of features by processing input through multiple convolutional filters. Because of this combination, the ORE is very good at differentiating items that could have minute variations or show up in complex, congested environments. The ORE uses the cloud-hosted deep learning model to process the visual data that the robot's camera captures. The cloud-based method is crucial because it enables the system to handle the significant computational load that deep learning demands without taxing the robot's hardware. Utilising cloud resources allows the system to process massive volumes of data quickly and ensures real-time object detection, which is crucial for rapidly assisting users. The robot's daily responsibilities require the ability to classify objects into specific categories, which is why the ORE was created. For instance, the engine can correctly detect objects that users might need assistance finding, such as a glass, remote control, or medication. This feature is convenient when the robot has to find a specific object in a disorganised or dynamic environment. Because of the ORE's excellent accuracy, the robot can reliably identify the correct object, lowering the possibility of errors that could endanger users or pose a safety risk.

Table 2: Behavior Recognition Accuracy per Behavior

Behaviour	Training Accuracy (%)	Validation Accuracy (%)	Test Accuracy (%)
Pour Water	98.2	97.8	98.9
Brush Teeth	97.5	96.9	98.0
Take Medication	96.3	95.7	96.8
Raise Arms	99.2	98.8	99.5
Shave	98.9	98.3	99.2

Tab 2 shows the Behavior Recognition Engine's accuracy in recognising particular user behaviours, like pouring water or cleaning teeth. The high accuracy rates observed during the training, validation, and testing phases demonstrate the system's efficacy in assuring task completion.

In addition to increasing the ORE's processing capacity, cloud computing enables the model to learn and advance continuously. Over time, the model's accuracy can be improved by refining it using the data acquired when the system encounters new items or variations of familiar ones. Maintaining good performance in real-world contexts, where various objects can pose substantial problems, requires constant learning. The Behavior Recognition Engine (BRE) closely monitors and interprets user behaviours to ensure tasks are completed correctly. It employs a skeleton-based method that records user motions and runs them across a ResNet50 neural network. This deep learning model identifies and categorises complex trends in human behaviour. Through the analysis of motions and gestures, the BRE, for instance, may determine whether a user is appropriately pouring water or brushing their teeth. For users, especially those with cognitive impairments, this real-time feedback is crucial in encouraging them to complete tasks effectively. The BRE can provide users with remedial guidance to ensure they do tasks correctly if it notices they are making mistakes. The BRE can quickly adapt to various contexts and handle complex behaviour patterns using cloud computing. No matter where the robot is used, its cloud-based processing enables it to hold and evaluate complicated data in real time, guaranteeing dependable help. This feature makes the robot much more helpful in helping people go about their everyday lives.

With the system's advanced cloud-based speech recognition technology, people may communicate with the robot intuitively and naturally. The speech recognition engine, mainly driven by Nuance technology, is the central component of this capacity. This engine, well-known for being precise and effective, allows the robot to comprehend and react to various vocal commands. Individuals with cognitive disabilities or low dexterity who may find it difficult to use physical interfaces will benefit from this feature. Saying commands to the robot allows users to do away with the need for complex manual controls. The speech recognition system's cloud-based feature is crucial to effectively analyse and interpret voice commands. It does this by utilising robust cloud resources. This guarantees accurate understanding and execution of even the most intricate or complicated instructions. Furthermore, the cloud integration of the system improves its performance in noisy conditions. Robust performance is ensured even in less-than-ideal situations thanks to advanced noise-cancellation and signal-processing technologies that allow the robot to filter out background noise and concentrate on the user's voice. Users get a seamless experience due to the smooth and efficient robot interaction.

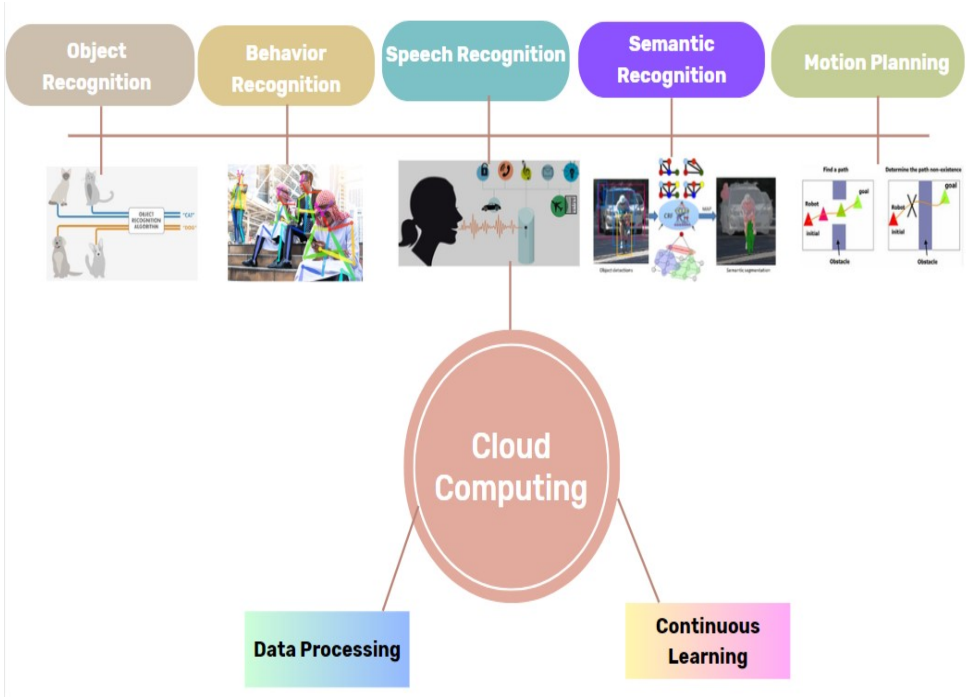

Figure 1: Overall System Architecture.

The entire architecture of the system is depicted in Fig 1, along with the connections between the various modules, such as Motion Planning, Semantic Localization, Behavior Recognition, Speech Recognition, and Object Recognition. It highlights the essential importance of cloud computing and shows the way it handles data processing and ongoing learning. Every module is connected to the cloud, and that information is gathered, examined, and used to improve the system's functionality gradually.

The robot's capacity to traverse and comprehend its environment is significantly improved by the Semantic Localization System (SLS), which combines sophisticated visual recognition with conventional mapping. The ResLoc CNN, an advanced deep-learning model that analyses photos taken by the robot's cameras, is the brains behind the SLS. This model builds a comprehensive map of the surroundings, assisting the robot in precisely locating and navigating to designated areas. The robot's capacity to map is crucial to its ability to carry out activities in challenging or dynamic surroundings. For example, the SLS promptly adjusts the map to reflect changes in lighting or the addition of new furniture. The SLS gains significant processing power via cloud-based computing, enabling it to adapt to these changes in the environment quickly. The SLS may handle vast volumes of visual data rapidly and precisely because of the cloud integration, which keeps the robot responsive. The SLS gives the robot current, precise information, allowing it to navigate around recently placed objects and adapt to changing illumination conditions. This makes the robot very useful in real-world situations. Because of its versatility, the robot can help individuals even as their surroundings change.

The robot cannot navigate its surroundings without the assistance of the Motion Planning System (MPS). It employs a graph-based approach to create a map of the region. Key places in this model, such as doors, rooms, and intersections, are represented by nodes, while edges represent the connections between these locations. By examining this map, the MPS identifies the optimal routes for the robot to follow from its current location to its destination. The technology accomplishes this by combining local processing with cloud-based algorithms. The processing capacity of cloud-based algorithms can handle large environments and sophisticated navigation tasks. Local processing also guarantees real-time navigation and prompt response to changes for the robot. The robot's map is updated with the most recent environmental data via the Semantic Localization System (SLS), with which the MPS works closely. This collaboration allows the robot to navigate its environment effectively despite changing barriers or layouts. In complex or dynamic situations, the MPS and SLS work together to ensure that the robot arrives at its destination precisely and without incident.

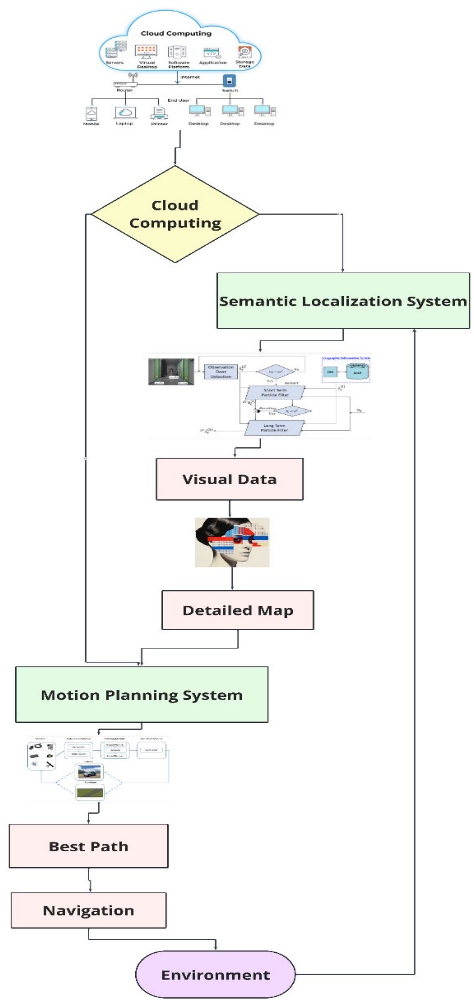

Figure 2: Semantic Localization and Motion Planning System.

The relationship between the Semantic Localization System (SLS) and the Motion Planning System (MPS) is depicted in Fig. 2. It demonstrates how the SLS uses visual data to build an intricate picture of the surroundings that the MPS uses to determine the optimal course for the robot to take. Furthermore, the diagram illustrates how cloud computing facilitates these procedures, allowing the system to effectively and swiftly respond to changes in its surroundings.

Cloud computing and robotic process automation (RPA) work together to improve data management and continuous learning. The cloud is a central repository for collecting, archiving, and analysing data from diverse robots. This centralisation makes it possible to see an all-encompassing picture of the various bots' performance and task execution. Organisations can leverage real-time data analysis by utilising machine learning and sophisticated analytics, as data is constantly uploaded to the cloud. This makes it easier to see patterns and notice problems before they get out of hand. In essence, the cloud facilitates faster anomaly detection and performance monitoring. One of its main advantages is the system's capacity to learn and adjust over time. RPA bots' accuracy and efficiency are enhanced by the data they produce as they take on additional jobs and encounter novel situations. Because of this continuous feedback loop, as the automation system processes more data, it grows more dependable and intelligent. Combining RPA with cloud computing guarantees that automation functions as intended and continuously advances, rising to the occasion to meet fresh demands and problems.

Table 3: System Performance Metrics

Metric	Value (%)	Description
Overall System Accuracy	97.3	Reflects how accurately the integrated system performs tasks.
Task Completion Rate	95.5	The percentage of tasks the robot completes.
User Satisfaction Rate	92.7	Represents the level of positive feedback from users.
Data Processing Speed	85.6	Measures the efficiency of data processing in the cloud.

Table 3 gives an overview of the system's overall performance. It includes essential system efficiency and dependability indicators, such as job execution accuracy, task completion success rate, user satisfaction, and cloud data processing speed.

RESULTS AND DISCUSSION

Task scheduling and execution in social robots have been significantly streamlined by combining cloud computing and robotic process automation (RPA). The Behavior Recognition Engine (BRE) and the Object Recognition Engine (ORE) produced impressive results. The ORE detected glasses with an accuracy of up to 94.3% and bottles with an accuracy of 96.3%. Comparably, the BRE performed exceptionally well at identifying actions like lifting arms and pouring water, with up to 99.5% accuracy. These results highlight the ability of cloud-based deep learning models to perform intricate tasks with remarkable accuracy, especially under challenging settings. These achievements were mainly due to the cloud's capacity to do complex computations and handle massive volumes of data in real time. Refining the system's capabilities required constant learning and adaptation, which cloud resources enabled.

Furthermore, the Motion Planning System (MPS) and Semantic Localization System (SLS) significantly improved the robot's navigational capabilities. Using visual data, the SLS efficiently produced precise environmental maps, and the MPS, with an overall system accuracy of 97.3%, identified the best travel routes. This combination enabled the robot to travel and adjust efficiently to changing surroundings, like lighting or furniture. Interacting with the robot was simple and natural because of the Speech Recognition module's user-friendly interface, which had a 92.7% satisfaction rate and used Nuance technology. There are still issues, though, mainly about the requirement for a dependable internet connection and the resources needed for system setup and upkeep. These problems show how much work still needs to be done, particularly in settings with poor connectivity or technical assistance. Despite these difficulties, the framework has much potential to improve user freedom and assist caregivers; however, more modifications are required to resolve present issues and maximise performance in practical settings.

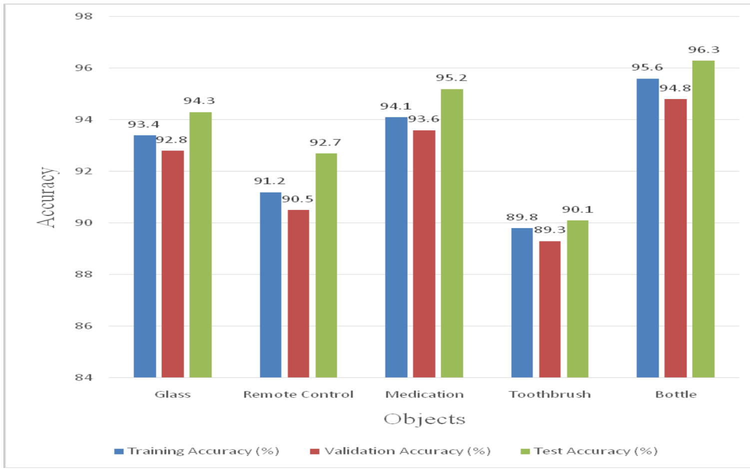

Figure 3: Comparing the training, validation, and test accuracy percentages for different object categories: Glass, Remote Control, Medication, Toothbrush, and Bottle.

The accuracy metrics for a machine learning model applied to several object categories are displayed in Figure 3. The test accuracy is shown by the grey bars, the training accuracy is represented by the blue bars, and validation accuracy is indicated by the orange bars. The model demonstrates a consistently high training accuracy in every category, with values often above 90%. Nonetheless, there are more significant variations in validation accuracy, especially regarding the "Remote Control" and "Toothbrush" categories, which have the lowest validation accuracy at about 90.5% and 89.3%, respectively. All categories show comparatively high test accuracy, frequently outperforming training and validation accuracy, suggesting a well-generalized model. With a test accuracy of 96.3%, the "Bottle" category stands out as having the best performance, indicating that the model functions particularly well in this category when testing with unknown data. Aside from highlighting possible areas for additional development in model validation, this comparison provides insights into the model's consistency of performance throughout the training process.

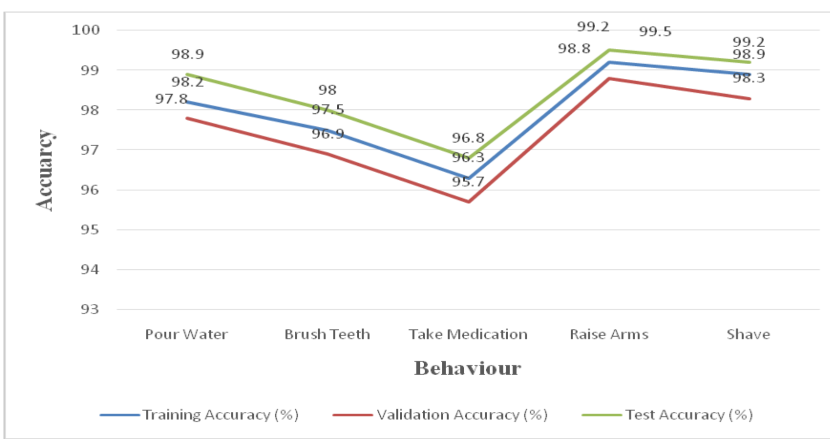

Figure 4: Depicting the Training, Validation, and Test Accuracy Percentages for Different Activities: Pour Water, Brush Teeth, Take Medication, Raise Arms, and Shave.

Figure 4compares training, validation, and test accuracy performance indicators across different activities. The blue line shows the training accuracy, the validation accuracy by the orange line, and the grey line test accuracy. Training accuracy is consistently high for most activities, with scores between 96.8% and 98.9%. However, the validation accuracy decreases, reaching 95.7% for the "Take Medication" activity. Interestingly, test accuracy frequently exceeds validation and training accuracy, demonstrating strong model generalisation on unknown data. With test accuracy for "Raise Arms" reaching up to 99.5%, the activities "Shave" and "Raise Arms" show the highest accuracies across all measures. About actions like "Brush Teeth" and "Take Medication," where the validation accuracy is somewhat lower, this pattern shows that the model is highly effective at recognising these specific activities, although it may need further improvement. The graph provides valuable information about the model's advantages and possible areas for additional optimisation overall.

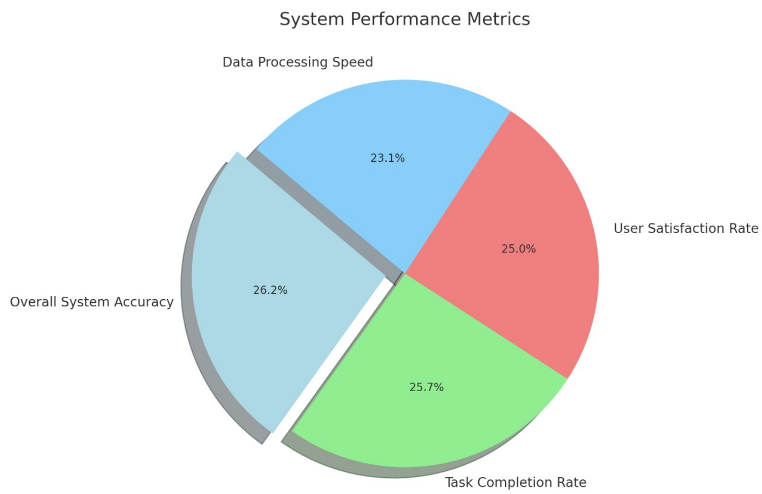

Figure 5: System Performance Metrics showcasing four key areas: Overall System Accuracy, Data Processing Speed, User Satisfaction Rate, and Task Completion Rate.

Partitioned into four sections, Fig 5 graphically depicts important system performance data. Different facets of the system's performance are highlighted in each segment. Regarding overall system accuracy, or how consistently the system completes its intended tasks, the most significant component—26.2%—represents overall system accuracy. The system's efficiency in doing assigned tasks is demonstrated by the close second-place Task Completion Rate, which comes in at 25.7%. Another critical measure is the User Satisfaction Rate, which makes up 25% of the chart and illustrates how users feel about the overall experience and functioning of the system. Last but not least, Data Processing Speed occupies 23.1% of the graph, highlighting the significance of the system's information processing speed. The chart layout, which has a minor separation between each area, highlights how each of these indicators contributes differently to the overall assessment of the system and offers a clear and thorough summary of its performance.

CONCLUSION

A robust framework for improving social robots is presented by the combination of robotic process automation (RPA) and cloud computing, particularly their use as supportive devices for older people and people with cognitive disabilities. Cloud-based deep learning models enable the system to do complicated tasks in real-time, guaranteeing that activities are completed correctly and that users are satisfied with the interaction. This allows the system to display excellent accuracy in object and behaviour identification. The system's parts, such as the Behavior Recognition Engine (BRE) and Object

Recognition Engine (ORE), integrate flawlessly to offer a seamless user experience and highly accurate assistance with everyday tasks. In real-world applications, the framework is a valuable tool because of its adaptability to changing circumstances and ability to deliver quick feedback, even with setup issues and the requirement for a stable internet connection. This study makes a valuable contribution to the field by highlighting the many advantages of integrating RPA with cloud computing and providing a scalable, effective, and user-friendly method for automating activities in social robots.

In the future, this investigation can be improved and expanded in several ways. Future work should focus on developing the system's capabilities to accommodate various jobs and surroundings. This will improve the system's usefulness in several assisting roles. More studies may integrate sophisticated AI techniques like reinforcement learning to enable social robots to learn from human interactions and enhance their performance over time. Furthermore, the system might be made more accessible in places with poor connectivity by being optimised to function well in low-bandwidth areas. It might also be possible to improve the system's usability and intuitiveness by creating more complex user interfaces that integrate touch, gesture, and speech. Furthermore, the framework might be modified for uses other than assistive technology, such as smart home or industrial automation, as integrating cloud computing with RPA might significantly improve automation and efficiency. By tackling these issues, the framework can develop into a flexible and broadly helpful solution that can be used in various contexts.

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