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Review Article

Improving Educational Productivity Towards Sustainability Using AI and Robotics Solutions for Administrative Optimization: A Comprehensive Review

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Abstract - *The tedious, error-prone, and laborious manual system for recording and consolidating marked examination scripts in institutions drains educators' resources, which could be used more effectively in fulfilling teaching-learning experiences. Curriculum review. This use of AI and robotics is designed to simplify educators' administrative workload, allowing them to spend more time strategically planning for the classroom and tackling complex problems. Descriptive methodology is employed in this review study to identify how the implementation of AI and Robotics processes enhances the instructional efficiency of educational productivity, as well as its sustainability for administrative optimisation. A systematic literature review was conducted using the Web of Science, Scopus, and ScienceDirect databases, covering different keywords from 2014 to 2025. The discovery of the third variety is obtained through investigations of conventional automated educational data management systems, robotics and automation in education, and image processing techniques for grade records. The methods employed for extracting student details are also discussed, along with their advantages and drawbacks. This investigation also introduces the suggested robot arm and AI system for administrative optimisation and sustainability. The overview, the component architecture, and the web application backend development project organisation. Compliant with Sustainable Development Goal 4, this paper presents the role of technology in transforming conventional educational systems. It also introduces implications for other SDGs, such as SDG 9 and SDG 17, highlighting how AI and robotics are transformative in educational management. The study concluded that the application of AI, Machine Learning, and robotics Techniques in the educational administrative process will significantly improve the education system.*

Keywords - *Student grades recording, Artificial Intelligence, Machine Learning, Image processing, Computer vision, Robot Awareness, Educational technology, Sustainable development goals.*

1. Introduction

In our educational institutions, the traditional manual recording and collation of graded examination scripts presents a time-consuming and labour-intensive endeavour. The tendency of the process to be inefficient and error-prone adds even further complexity to the challenge [1]. It has caused educators to invest substantial time and effort in such administrative tasks to meticulously record the students' scores [2]. Even worse is that the arduous nature of manual data entry diverts the educators' valuable resources from more impactful teaching and learning activities, which would, in turn, hinder an overall educational experience or learning cycle in our institutions down the road [3]. Moreover, the reliance on manual data entry could also elevate the risk of data inaccuracies and delays, which could, in turn, compromise the integrity of student records, thus leading to miscommunications and discrepancies in assessment outcomes and consequently hindering the educators' ability to make well-informed decisions based on timely and accurate data [4]. Given the already outlined challenges faced with the traditional recording and collation of students' graded scripts and the importance of such tasks, blending efficiency in managing things and introducing new technologies to drive automation becomes important [5]. This is why educational institutions have increasingly emphasised the need for optimising administrative processes with the rise of artificial

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intelligence, thus changing things in a big way. The introduction of Artificial Intelligence (AI) brings significant benefits to any administrative domain, as its automation capabilities could help liberate valuable time by taking up routine tasks, enabling administrators in such a domain to focus on strategic planning and complex challenges [6]. Moreover, it also reinforces the integrity of administrative processes in that domain by minimising human errors through its capability for precision and accuracy, thus fostering reliability and trust in many data-driven decisions [7].

Therefore, any educational institution looking to prioritise administrative efficiency and data-driven decision-making could use an intelligent and automated solution for handling most-if not all-of its administrative tasks. An example of such a task, as already mentioned in the first paragraph, would require streamlining the script handling process with the employment of an integration of several concepts ranging from the field of artificial intelligence to that of robotics. The convergence of both fields would imply the utilisation of sophisticated image processing algorithms to fulfil student information retrieval from the scripts and robotic manipulation and control algorithms to fulfil faster examination script handling. Indeed, by appropriating these aspects, not only are the problems of manual data collation resolved, but is also reiterates that technology has a great potential to enhance and supplement educational functions such that when the lines between 'innovation' and 'education' blur we can point to an intelligent automated students' marks collation system as example of how technology is a natural facilitator for meeting those ends.

This paper discusses a comprehensive review of the essential notions in developing an intelligent student's marks collation system through Artificial Intelligence (AI) and Robotics. Perhaps more significantly, by considering current literature in the field of automation of educational data management, awareness, and manipulation for robotic and automation technology domains, as well as image capturing, pre-processing, and data extracting methodologies, a foundation was successfully built for an innovative perspective in administrative efficiency at schools. In focusing on efficiency in education, the paper shares a common agenda with SDG4 of “quality education” for all. But it has a significance that goes beyond this aim, with ramifications for other SDGs, in particular SDG 9 “Industry, Innovation and Infrastructure” and SDG17 “Partnership for the Goals”.

Through promotion of the use of AI and robotics in school administration, this paper highlights how technology can transform established processes, enabling educators to reclaim valuable time and resources for strategic planning and solving much more complex problems. Additionally, administrative processes can be more reliable and trusted in making data-driven decisions, given the precision and accuracy this technology provides. In other words, this review helps guide the way for the development and application of smart solutions that will change the educational management, leading to sustainable education. Furthermore, this study aims to focus on improving educational productivity towards sustainability using AI and robotics solutions for administrative optimisation by carrying out a comprehensive review of literature and discussing the challenges and way forward.

2. Automated Solutions for Educational Data Management

The increasing integration of technology into educational processes and the continual progress of computer systems have allowed for the collection and storage of large volumes of data associated with educational systems. However, educational institutions face enormous problems digesting this data to draw relevant insights. In fact, according to [8], the sheer volume of data emanating from multiple sources and in varied forms exceeds human capabilities for unassisted analysis and significant information extraction, and this is why automated analytical approaches are used to extract essential knowledge from raw data, a process critical for making educated decisions. Educational Data Mining (EDM) was developed to extract relevant insights that might influence companies. It derives from three major fields: statistics, computer science, and education (as represented in Figure 1). The intersections of these domains give birth to similar subdomains that are closely connected to EDM. Computer-aided education, data mining, and analytical learning are examples of these.

The emerging field of data mining for education is concerned with creating methods for analysing particular data from educational settings in order to enhance students' and their learning environments' comprehension [9]. The goal is to turn fundamental educational data into insightful knowledge that can be applied to research and decision-making. Despite being adopted more slowly than other fields, data mining and analytics in education have made progress. However, because of its distinct features, handling data from online learning is challenging. The temporal distribution of educational data is unique, even if all data types include sequential elements.

For example, a skill may be repeated throughout the school year but in different circumstances. Educational data mining has successfully modelled many student learning phenomena in intelligent online systems. The accuracy of these models increases year after year, and their usefulness expands. Several essential factors support the distinct growth of educational data, and these include recognising that crucial information is not isolated to a single data stream, improving model quality through improved approaches, and admitting the presence of more documented detector instances than real intervention situations are among these [10].

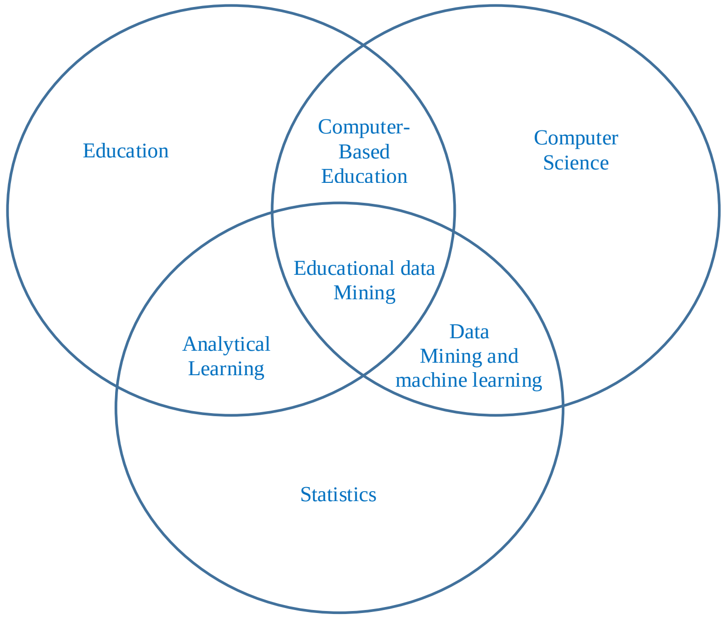


Fig. 1 A diagrammatic representation describing the domains of EDM

Upadhyay & Katiyar [11] state that educational data mining generally unfolds in four stages. The primary stage focuses on discovering relationships hidden within the data of the educational setting; these interactions are critical because they serve as the foundation for numerous data mining approaches, such as classification, clustering (described in Figure 2), and regression. Once these links have been disclosed, the next phase entails a vital task: verifying them. This stage tries to confirm that the detected associations have true significance and are not purely accidental, thus reducing the danger of data overfitting. Following successful validation, the third stage begins, in which these authenticated associations are used to anticipate future events and trends in the learning environment. This predictive skill enables educators and institutions to change and improve their techniques. Finally, in the fourth step, these forecasts are used as instruments for informed decision-making to improve the results and experiences of the learning environment. Predicting how well students will do in their studies is a big deal in Educational Data Mining (EDM), so it is getting more attention [12, 13]. By making these predictions, we can determine which students might struggle academically. This helps educators step in early with guidance or help, keeps track of how students are doing to improve their learning path, and suggests suitable learning materials.

According to the study in [14], the CRISP-DM is a Cross-Industry Standard Process that some researchers utilise to develop a student-performance prediction model. They explain that six necessary steps form the CRISP-DM execution process, the first of which involves knowledge of the business's objectives, an imagination of its purpose, and an articulation of the function of the Data Mining (DM) project. This first phase requires project planning, constraint identification, and an emphasis on identifying the DM task needs. The second step would be to comprehend the data environment, find the necessary data tables and fields, and examine data features, which are all part of the process. The third step focuses on data preparation, which includes data integration, cleansing, and possible transformation. The next phase is model creation, which includes the design and construction of analytical models. The model is then evaluated through experimental testing. The predictive model is refined and pushed out in the last step, deployment, depending on its anticipated use.

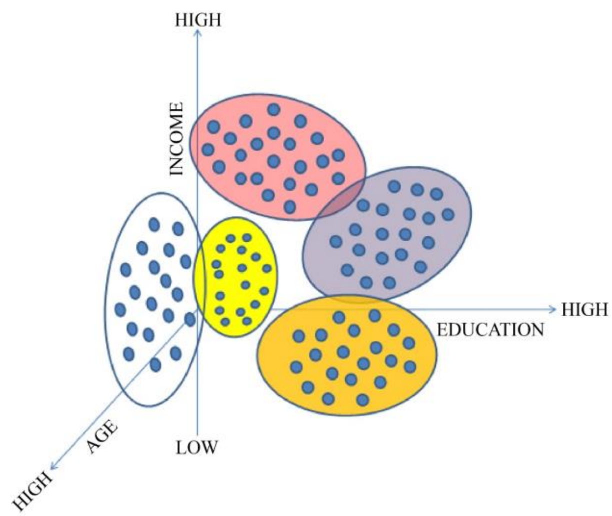


Fig. 2 A Diagrammatic Description of a Clustering Algorithm (An Actual Cluster Analysis of the Incomes and Outcomes in Europe's Education presented by [15])

Kaur et al. [16] focused on identifying students with slower learning progress using a predictive data mining methodology and classification algorithms. He used a real-world dataset from a high school, with the open-source program WEKA assisting in identifying critical variables. The student academic records dataset is examined and applied using WEKA to numerous classification methods. As a result, statistical results for each classification technique are generated, followed by a complete comparison of these five classifiers. This comparison aims to assess accuracy levels and identify the best-performing categorisation method. Finally, the results show that Multilayer Perception is the best performer, with a 75% accuracy rate. Sivasakthi [17] conducted a study to predict the success of first-year undergraduate students in a Computer Course Application based on their introductory programming ability. This was accomplished using classification-based algorithms in a predictive data mining strategy. Student population size, scores in college-level introductory computer programming, and grades on an exam consisting of 60 programming problems were all included in the dataset. Using the WEKA program, the obtained data was exposed to numerous categorisation methods, including Multilayer Perception (MLP), Naive Bayes, SMO, J48, and REP Tree. This method produced statistical analysis generated from all of the categorisation algorithms. These statistics were used to thoroughly compare the five classifiers, with the primary goal of predicting accuracy and determining the most effective classification technique. According to the study's findings, the MLP algorithm performed best, with an accuracy rate of 93%. As a result, the MLP algorithm displayed significant promise and efficiency as a classifier, as evidenced by the study's findings. By eliminating unnecessary data from the educational dataset, Feature Selection (FS) algorithms can also improve classifier performance during educational data mining. Since educational stakeholders must base their decisions on the outcomes of prediction models, choosing pertinent features for student prediction models is a vulnerable problem.

For this reason, the study in [18] studied the evaluation of six unique Feature Selection (FS) methods. Cfs-Subset-Eval is one of the algorithms tested, and it determines feature relevance by considering individual predictive prowess and feature redundancy. The second approach was Chi-Squared Attribute Eval, which computes attribute significance using chi-squared statistics relevant to class associations. The third technique, Filtered Attribute Eval, works by ranking and choosing characteristics based on their significance to a target variable as defined by a specified evaluation measure. Gain Ratio Attribute Eval, the fourth algorithm, provides a non-symmetrical measure to correct information gain biases. The sixth approach was the Principal Components algorithm, a dimensionality reduction strategy that involves converting original variables into new, independent components that embody critical information while keeping variation. Finally, Relief Attribute Eval evaluates attribute importance by incrementally selecting examples. This work aims to highlight the strengths and limits of each FS method, leading to a better understanding of their value across different datasets and problem areas.

Figueira [19] predicted students' future grades after talking about the statistical evaluation of the three primary features that were taken from Moodle records, and showing how they cannot be utilised separately to model our data, we used principal component analysis to create a decision tree according to these characteristics. Although each of the selected attributes provides significant descriptions of student behaviour, the analysis revealed that when they are accessible in isolation, various issues arise. However, using principal component analysis, he was able to choose the most influential traits after integrating all three key features. Table 1 presents a summary of approaches and outcomes in educational data mining. With these studies, it can be confirmed that the significance of effectively representing students' information, such as their grades, has been presented in the literature.

Table 1. Examination of approaches and outcomes in educational data mining studies

Authors	Problem/ Objective	Algorithm/ Technique used	Findings/gaps
Duane et al., [20]	In grouping categorical data, compare a novel algorithm to established clustering approaches.	Entropy-based K-modes clustering algorithm (ER-k-modes).	Regarding purity, clustering accuracy, and F1-measure, the ER-k-modes outperform the traditional technique regarding accuracy and convergence capability.
Singh et al., [21]	It analyses students' academic performance and the elements that influence it methodically.	Multiple Regression Analysis as a method within the structure of a post facto research strategy	According to the research findings, a student's academic success is significantly impacted by their learning environment, interpersonal skills, and advice from parents.
Rana & Garg, [22]	Evaluate students' performance in the third semester of Information Technology, with the course of study being Digital Electronics.	The application of hierarchical clustering and classification methods like NB and LR.	A hierarchical algorithm has a lower average predictive accuracy than the K-means algorithm. However, they both are better when compared with naïve Bayes or Logistic regression. However, they are all fast algorithms.

Batool et al., [23]	A comparative study of 260 research studies over the last 20 years presents the best tools for predicting student performance.	Clustering algorithms; Classification algorithms; WEKA tool	According to the findings, Artificial Neural Networks (ANN) and Random Forest emerge as widely used approaches in data mining. Concurrently, WEKA is a well-known platform for predicting students' academic progress. Furthermore, the research emphasises that individuals' educational histories and demographic factors are the most relevant factors in predicting academics.
Wongvorachan et al., [24]	To demonstrate how imbalanced learning techniques can address class discrepancy in an informative dataset with varying levels of discrepancy and evaluate their effectiveness in improving performance.	Hybrid Minority Stochastic Oversampling Technique for Numerical and Continuous	The performance of imbalanced learning techniques in arrangement tasks varies contingent on the degree of discrepancy in class proportion in the target variable. Random Over-Sampling (ROS) is the most effective for the Random Forest Classifier among these techniques.
Aurora & Badal [25]	Determine whether students are performing poorly this semester by comparing their grades to those of degree and post-graduate students from prior semesters.	Association Analysis Algorithm; WEKA	This helps to result in excellent placements, consequently increasing the quality intake of students.
Alghamdi & Rahman [26]	Predict the performance of early secondary students	Naïve Bayes, Random Forest, J48, and SMOTE techniques	The Naïve Bayes algorithm proved to be the best-performing
Dol & Jawandhiya [27]	Analysing classification and clustering algorithms and other data mining methods, in particular, enhances the understanding of the students' teaching process and grading academic performance.	Naïve Bayes, Random Forest, K-means clustering algorithm, association rule algorithms, Weka	According to the analysis's findings, clustering techniques like K-means are frequently used in conjunction with classification techniques like NB, RF, and SVM to evaluate students' performance in educational data mining. These techniques show noteworthy performance based on metrics like accuracy, precision, recall, f-measures, and k-fold validation.
Anuradha et al., [28]	To demonstrate how clustering techniques used in educational data mining may group students into clusters based on academic performance and learning patterns.	Clustering algorithms	Findings show that a commonly used clustering algorithm is the K-means clustering algorithm for evaluation and exploration.
Pérez et al., [29]	Detect students dropping out of the Engineering program, known as Systems, after six years in a Colombian university.	Decision Trees (DT), Logistic Regression (LR), Watson Analytics, Naïve Bayes (NB), Random Forest (RF);	From these findings, it was discovered that the performance of systems engineering courses was correlated with the enactment of the students in physics and mathematics courses.

3. Awareness, Manipulation in Robotics and Automation

Robotics and automation have seen tremendous progress over the past few decades, leading to unprecedented technological development. Those sciences or technologies that only existed in the world of fantasy or science fiction have now become important domains playing a key role in various areas (manufacturing, banking, education) and so on, affecting our daily life. This extraordinary revolution was built on a momentum of robotics and automation, in perception skills and manipulation capabilities; the uncanny capability of robots to see, analyze, and interact with their environment has emerged as the most significant source of innovation. The dawn of the era of innovation "Smart Manufacturing for Future" According to [30], such an age of innovation is characterized by a relentless pursuit in defining how Industry 4.0 will be successful, i.e., reach its goal. and it is the encroaching network of robotic and Artificial Intelligence (AI) capabilities, poised to transform the core of our businesses, society, and daily lives, that forms its vision.

Meanwhile, while we're still enjoying the development of an increasingly transformative fourth industrial revolution landscape, there's a captivating new age phenomenon on the horizon in the form of industry 5.0, where humans and robots – or 'human-robot collaboration' – collaborate in production completion! [31] categorizes a self-aware system as one that is able to adapt better when experiencing unknown situations as compared to a non-aware system. The self-conscious system monitors and can also reflect on its internal dynamics (and thus it is amenable to introspection and self-normalization). In order for a robot to be truly self-aware, it must also have the ability to recognize its internal state. These internal states encompass emotions, beliefs, desires, intentions, expectations, and processes like sensation, perception, conceptualisation, simulation, action, planning, and cognition. Throughout any recognition process, the robot's awareness of its emotions, perceptions, beliefs, and objectives becomes indispensable. Without awareness, robot developers would be compelled to explicitly outline every action and behaviour, ensuring the robot functions according to its intended purpose and design objectives. This task becomes incredibly challenging when dealing with open, intricate, and constantly changing environments. In such scenarios, specifying precise actions and behaviours for all potential conditions and situations becomes an onerous endeavour. Conventional robot development approaches, tailored for well-defined problems, do not readily adapt to the complexity and dynamism of such environments. The sheer magnitude and potentially infinite variety of circumstances to account for make it impractical to expect that robot developers can anticipate and design suitable responses for all conceivable scenarios.

This is why [32] argue that self-awareness is a characteristic difficult to deploy on robots, as it is a broad term adapted from cognitive science and psychology that describes the characteristic of a system that knows 'itself' based on its logical sense and internal representations (where this knowledge could take different forms founded on perceptions of both internal and external phenomena, and is crucial for being able to foresee and respond to unknown situations). The difficulty level is defined by specific fundamental challenges, which require autonomous robots to develop the capacity to learn inference models from sensor inputs, determine the current state and the present condition of their surroundings using these models, and detect any anomalies in observed behaviour compared to inferred behaviour. Therefore, extracting valuable information from sensory data is central to a robot's awareness, as it forms the foundation for perceiving and comprehending its internal and external environment. Increasing efforts regarding the design of the sensory perception and capabilities in robots would therefore result in increasing development of the robot's awareness capabilities, creating more impact in our sectors and lives. For example, [33] proposed an extensive case study illustrating the integration of advanced innovative sensing functionalities to a robotic arm manipulator (KUKA KR90 R3100) with the primary purpose to provide to the robotic system sufficient sensing capabilities in order to make it able to avoid collisions and plan its motion on line in a dynamic manner that is essential when navigating within dynamically changing environments. For that purpose, the developed machine vision module exploits cost-effective RGB cameras and a colour detection method using the Hue, Saturation, and Value (HSV) colour space. Such a strategy enables the sensor perception ability of the robot to sense and locate randomly moving obstacles in its working space. The achievement of this project relies on the proper integration among three interrelated components: machine vision, path planning, and robot control (described in Figure 3), which operate in parallel and keep the operation real-time and communicate continuously with each other. The machine vision module (in the role of server) follows dynamic obstacles continuously.

Another instance may be provided for the health domain where suturing works are needed to ensure proper closure in any surgical scenario. Talasaz et al. [34] addressed the crucial domain of Robotics-Assisted Minimally Invasive Surgery (RAMIS) and haptic feedback influence on suturing skill. These results emphasize the heterogeneity of haptic feedback, in that for tissue puncturing, we found visual force feedback to have marginal utility, as different users need different amounts of force depending on the depth at which they are piercing. But it was direct force feedback that won the day, enabling people to exert less force and therefore reduce damage. In conclusion, [34] highlights the significance of sensorimotor perception in medical robotics and provides a more nuanced view of haptic and visual feedback for enhancing surgical performance to progress RAMI as a discipline.

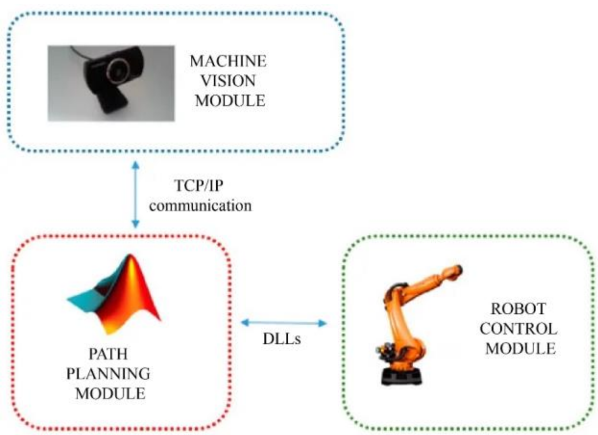


Fig. 3 The proposed system's overview with three concurrent modules

Kappassov et al. [35] said, "The final frontier for robots is not space, but our living rooms". This is why the field of robotics is expanding to include complex environments like our homes, hospitals, banks, and even schools. For robots and humans to work side by side in such complex environments to achieve common goals, it, therefore, becomes imperative for robots to learn to grasp and manipulate objects with dexterity while being 'conscious' of the presence of humans. George [36] reviewed the significance of tactile sensing in nimble-fingered robot hand operation, emphasising its role in providing information on interaction forces and surface properties at contact points. Tactile sensing, according to [36], is critical for achieving autonomous and effective dexterous manipulation with robot hands. Higher spatial resolution is advantageous for in-hand object manipulation and tactile feedback control. However, it is limited in cases requiring high sensitivity or frequency response due to longer acquisition time and increased susceptibility to electromagnetic interference. Sensitivity, defined as the lowest observable pressure/force fluctuation, is essential for sensitive object handling, yet also lowers dynamic range. Furthermore, limiting the amount of wiring on the workspace of the robot hand is critical, and it can be accomplished with integration issues handled by smart wiring, shielding, and protocols such as serial communication. When [37] utilised a bidirectional neuro-myoelectric prosthetic hand capable of biomimetic sensory feedback, they found that electromyographic signals from residual arm musculature drive.

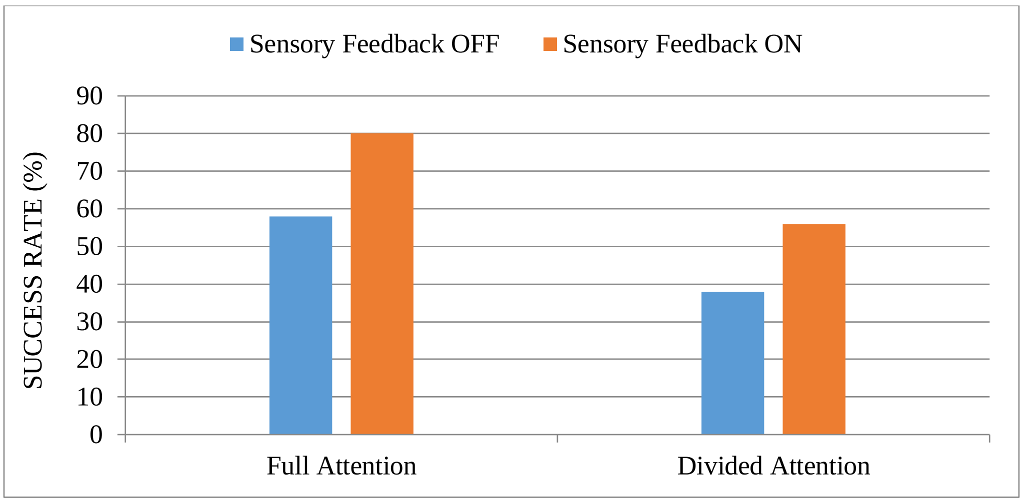


Fig. 4 Evaluating the success rate of the participant's task against enabled or disabled sensory feedback and a full or divided attention

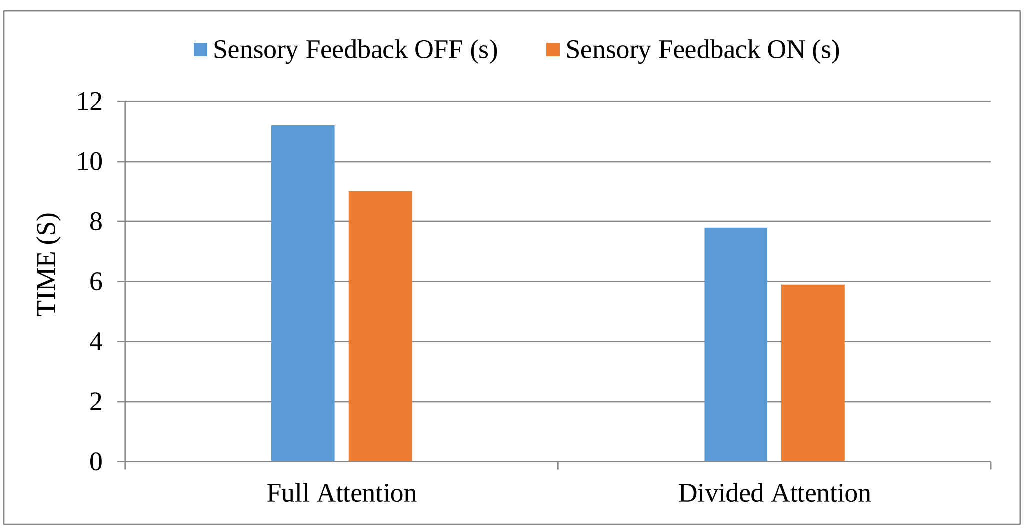


Fig. 5 Evaluating the speed of task completion against enabled or disabled sensory feedback and a full or divided attention

Moreover, in using the prosthesis' touch sensors, chronic implantation of Utah Slanted Electrode Arrays enabled intraneural micro-stimulation of surviving remnant sensory nerve fibres to generate tactile sensation in the phantom hand. The subjects showed improved grip force accuracy and dexterity when receiving sensory input. Through active research, it was also noted that the participant could distinguish between soft and hard materials and between minute and large objects. The task was performed with and without the sensory feedback functionality and with full and divided attention. The variable of split attention was relevant to evaluate since human actions frequently require dividing attention between numerous concurrent subtasks, like holding a container while turning off its lid.

To mimic split attention, the individual was instructed to complete the same activity while counting backwards. The experiment revealed that when participants were given sensory feedback, they moved the object more frequently and quickly. However, when participants' attention was divided, although the feedback-induced performance increase continued, the impact on duration remained statistically noteworthy (as described in Figures 4 and 5).

In a study by [38] focused on enhancing the neural inspiration provided to trans-radial with intra-neural electrodes, various encoding strategies were compared regarding their effectiveness and the naturalness of the tactile feedback they delivered. The findings of this research highlighted a critical balance between naturalness and efficacy in providing sensory feedback to these individuals. One key observation was that bio-mimetic frequency modulation was perceived as more natural, replicating a more lifelike sensory experience. On the other hand, amplitude modulation proved to be more advantageous for tasks demanding precise identification of applied force, enhancing overall performance.

Furthermore, this simultaneous modulation approach maintained high levels of manual accuracy; the hybrid encoding strategies advanced manual capabilities and positively impacted prosthesis embodiment. These strategies reduced abnormal phantom limb sensations, often called the "telescoping effect." Consequently, the study recommended the preference for hybrid encoding strategies in delivering sensory feedback to trans-radial amputees with intra-neural electrodes, and these hybrid strategies excelled in providing both highly sensitive and natural percepts, effectively enhancing the overall quality of life and functionality for individuals with limb loss. Table 2 shows the summary analysis of awareness of the manipulation of the evaluation system.

Table 2. Further examination of awareness and manipulation in automation and robotics

Authors	Objective/ Problem	Softwares/Tools Used	Findings/Gaps
Sharma et al., [39]	Dynamically construct hierarchical object-centric controllers for manipulation tasks that may be divided into several simultaneous subtasks.	Proposed method on Reinforcement Learning: Object-centric controllers: Force, Position, and rotation controllers.	Experiments in simulation and the natural world demonstrate how the suggested technique improves sample efficiency, zero-shot generalisation to novel test conditions, and simulation-to-reality transfer without fine-tuning.
Batista et al., [40]	Utilising identification methods to determine the inverse kinematics of a cylindrical robot arm.	Least Squares (LS) identification technique, Recursive Least Squares (RLS) identification technique, Particle Swarm Optimisation with a search space defined by RLS (RLSPO)	An improvement is brought to RLS, as it is a more complex method. Additionally, the findings indicate that the identification accuracy of RLSPO outperforms both LS and PSO.
Wong et al., [41]	Develop a strategy for the robotic arm to pick up and place objects using its six degrees of freedom and a two-finger gripper.	A more efficient variant of the Rapidly-Exploring Random Tree (RRT) algorithm is employed, known as CS-RRT (Changing Strategy RRT).	The disadvantages of existing RRT algorithms are addressed, resulting in a reduction of the CS-RRT algorithm's computation time by implementing a sampling radius counting mechanism.
Plooij et al., [42]	To develop a novel end-effector for trimming bushes	A morphological chart to make design decisions.	During the first evaluation, it was realised that the weight of the cables used to control the end-effector's DC servo motors contributed to a few malfunctions.
Mega lingam et al., [43]	Create a feedforward controller that ensures the robotic manipulator's ultimate position is resilient to uncertainty in the friction model.	A two-degree-of-freedom Robotic arm and a TMT (Two-Mode Theory) method for the 2 DOF manipulators.	It was fascinating to observe that all motions resistant to friction model uncertainty initially move away from the objective position before progressing towards it.
Hernandez-Mendez et al., [44]	design and model of a 6 DOF robotic arm for application in search and rescue missions in disaster-stricken areas	Robot Operating System (ROS), Moveit, and RVIZ; forward and inverse kinematics	This presents an inexpensive and much easier method of control.

Palacios et al.,[45]	To develop an interface to a robotic arm with a motion planner and 3D simulator on the aROS platform.	ROS (Robot et al.), URDF (Unified Robot Description Format, PID controller	The paper presented the possibility of visualising the state of a robotic arm during manipulation in environments.
Wolf's lag et al.,[46]	Justify the use of a virtual joystick to manipulate a robotic arm within a laboratory environment.	Kinova JACO robot arm, Robot Operating System (ROS), forward kinematics via Denavit-Hartenberg parameters	It was realised that a virtual joystick is preferred over a manual joystick for arm interaction. It also makes it simple to handle repetitive actions and load preplanned trajectories.
Littlefield et al. [47]	Develop an approach that makes open-loop controllers follow desired model cycles more accurately.	2-DOF robotic arm, Repetitive Control (RC) algorithm as opposed to the Iterative Learning Control (ILC) Algorithm	The RC algorithm was chosen because it provides a quick state transition to a new iteration at the end of each movement cycle.
Shahriar & Li [48]	A study to investigate the impacts of the repercussions of end-effector selection on the speed and success rate of robotic picking	An underactuated 3-finger hand, a custom-built vacuum-based gripper	The planning procedure impacts the end effector's picking success rate. The 3-finger gripper is more flexible, while the vacuum-based gripper is more straightforward and smaller.

4. Image Capture, Pre-Processing, and Data Extraction Techniques

A class of techniques known as "digital image processing" deals with applying computer algorithms to manipulate digital images. Manipulate here refers to applying computer algorithms to alter, enhance, or transform digital images for various purposes, such as improving their quality, extracting information, or achieving specific visual effects. Image processing could, therefore, be described as a process of improving an already-existing image or extracting significant information from it.

In research, [49] noted that an image's quality is always a critical factor in raising the likelihood that various image recognition applications would be successful. They claimed that since extracting features from unprocessed noisy pictures is more complex, high-quality images have a higher recognition or classification rate than unprocessed noisy images. Therefore, pre-processing is usually done before extracting characteristics from the picture to overcome application errors that may have happened due to low-quality images. Image processing techniques can be broadly classified into three categories (as described in Figure 6): image enhancement, image restoration, and image analysis.

Ignatov et al. [50] surveyed image enhancement algorithms, aiming to conduct a thorough and systematic analysis of various techniques in Image enhancement. Image enhancement is essential in image processing and primarily focuses on improving image quality for specific applications. According to [50], the two main categories of traditional methods are spatial domain processing, which directly modifies pixel information through techniques like modified histograms and improved unsharp masks, and frequency domain processing, involving transformations like Fourier, discrete cosine, and discrete wavelet transforms. He further stated that as image enhancement technology rapidly evolves, novel methods such as the retinex model, fuzzy theory, and neural networks have emerged. Specific methods highlighted in the survey include histogram equalisation, the Retinex model, visual cortex neural networks, and deep learning, each with advantages and disadvantages. Spatial domain methods are praised for their simplicity, low complexity, and real-time implementation. However, they face challenges like insufficient robustness and imperceptibility, as finding a universally effective method is hindered by factors such as algorithm non-universality, evaluation index choices, noise influence, and optimal parameter selection. The complexity of image enhancement technology necessitates a careful balance between method advantages and addressing inherent limitations. Figure 7 below describes the whole framework of image enhancement techniques in space.

In a research, [51] proposed an innovative deep-learning solution named Weakly Supervised Photo Enhancer (WESPE), and it was aimed at automatically translating images captured by cameras with limited capabilities into high-quality DSLR-like images. Unlike previous approaches requiring extensive annotated datasets for training, WESPE operates under weak supervision, thus eliminating the need for a large set of aligned original/enhanced photo pairs. The model is trained using two distinct datasets: one from the source camera and the other comprising high-quality images sourced from the internet (even if they are visually unrelated). The primary focus of the study lies in the comprehensive evaluation of the proposed solution's performance, in which they employed standard objective metrics, conducted a subjective user study, and introduced a virtual rater in the form of a separate Convolutional Neural Network (CNN) trained on Flickr data, to mimic human raters. This virtual rater is then used to provide reference scores for both original and enhanced images. The extensive evaluation, spanning many datasets such as DPED, KITTI, Cityscapes, and images from various smartphone generations, indicated that WESPE yields comparable or even superior qualitative outcomes compared to state-of-the-art, supervised methods. By sidestepping the need for a large annotated dataset of aligned pairs, WESPE introduces a practical and efficient approach to photo enhancement, showcasing its potential for real-world application. The emphasis on thorough evaluation, incorporating both objective and subjective assessments, strengthens the credibility of their findings, providing a valuable contribution to the field of image enhancement through deep learning.In an experiment, [52] compared the efficacy of three image-enhancing techniques at different degrees of image degradation. Three techniques were employed to improve picture contrast: Contrast-Limited Adjusted Histogram Equalisation (CLAHE), Histogram Equalisation (HE), and Adaptive Histogram Equalization (AHE). However, special attention was paid to IQI and SI percentage values. Furthermore, after applying each image enhancement approach to the test photographs, the study visually compared the improved photos. In this experiment, the system's resilience was essentially tested using four test photos.

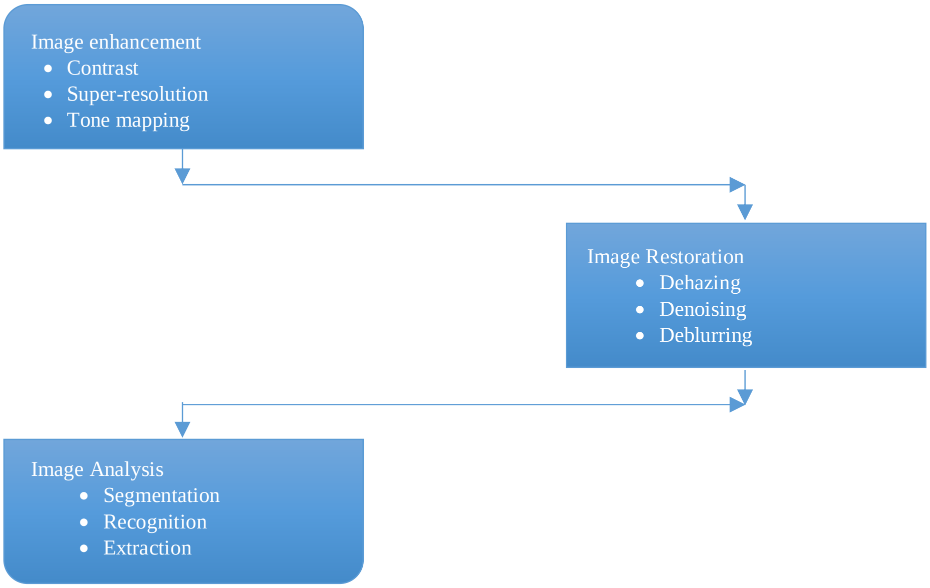


Fig. 6 The major categories in the field of image processing

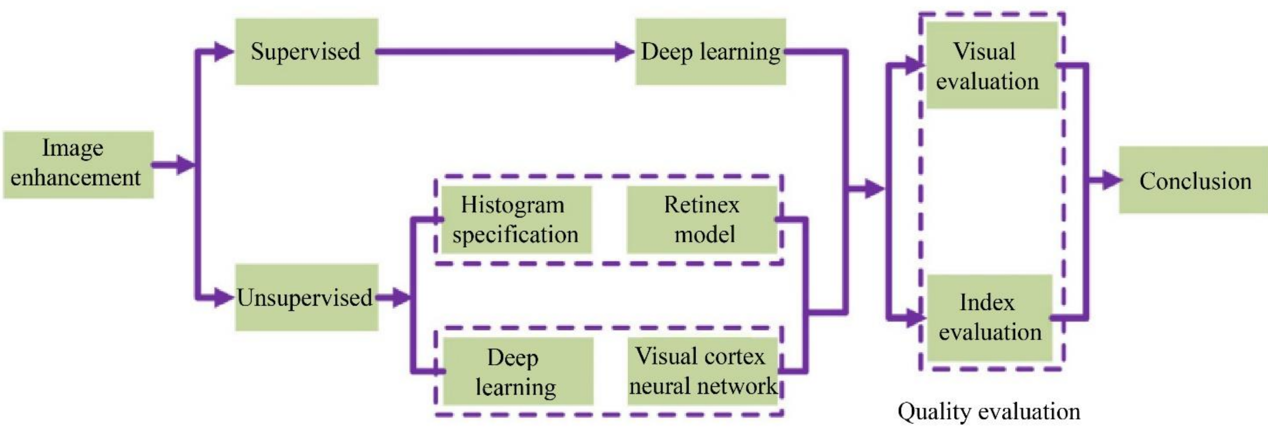
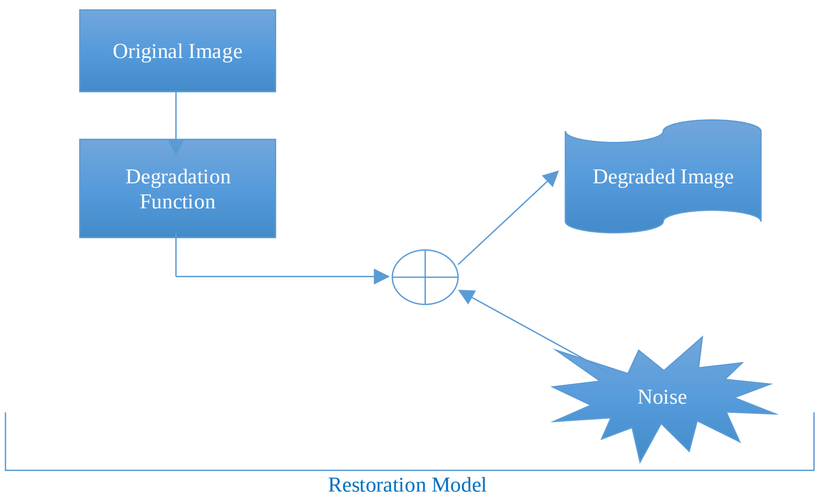


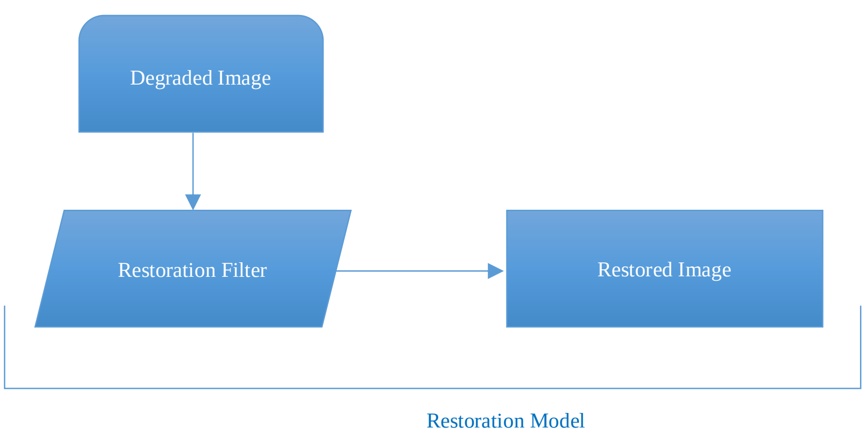
Fig. 7 A conceptual framework of what could be done during image enhancement

An upgraded picture with better contrast and visualisation was the resultant output. The original test picture and its output image are then contrasted. The outcomes show that the Histogram Equalisation (HE) methodology is an excellent way to enhance images and may be applied effectively to minimise picture faults. Stated differently, it may be applied to increase the contrast and visibility of pictures. As a result, the study demonstrated that histogram equalisation is the optimal image processing technique for boosting contrast in visually weak photos. Given that the study found that the histogram equalisation technique is among the best methods for enhancing contrast in image processing, the suggested method is hence defined as one that enhances both the computer analysis and human viewers' ability to interpret and perceive information in images. It can also be inferred that effectively managing vagueness and ambiguity in a picture may be achieved by applying the histogram equalisation image-enhancing approach. Therefore, it may be advised that any system, like ultra-scan sound machines, that analyzes pictures and outputs them to people for decision-making, incorporate the suggested contrast enhancement approach.

Kabiraj et al. [53] did a thorough comparative examination of methods for effectively eliminating noise from images, which is a difficulty made worse by changes in the surrounding environment or other variables. The main concern is noise problems that cause considerable degradation of images during capture or transmission by varying the pixel values, either by turning them on or off. The study clarifies the importance of image smoothing in image processing, where various filtering methods and algorithms are available, each with unique advantages and disadvantages based on a prior understanding of the noise. Recognising noise's critical impact on image deterioration, Singh and Shree broadened their scope by including a comparative comparison of noise reduction approaches. They stated that the image restoration process has two main stages: deterioration and restoration. The degradation model modifies the original image by adding blur and additive noise. In contrast, the restoration model uses filters to restore the degraded image (the entire process is shown in Figure 8). The goal of this second stage is to effectively eliminate blur and noise, giving an approximation of the original image. By applying previous knowledge of degradation phenomena, restoration filters aim for the best possible outcomes; specific methods work better in the frequency domain than others in the spatial domain, and the impact of restoration filters is usually gauged by the closeness of the approximated picture to the original. Table 3 depicts a summary of the different findings of this session.



(a)



(b)

Fig. 8 (a) The degradation model process, and (b) The restoration model process.

Table 3. Further examination of image capture, pre-processing, and analysis

Authors	Objective / Problem	Software or Tools Used	Findings/Gaps
Jin et al. [54]	Recognition of number plates from enhanced super-resolution	Rectified Linear Unit initiation and creative adversarial network improved-superior resolution layer; Optical Character Recognition (OCR) model	While the OCR model achieves an average precision of 84% for high-license resolution plate images, its accuracy drops to about 4-7% for low-resolution images.
Zhao et al. [55]	To investigate the possibilities of using deep learning techniques to diagnose illnesses from uncontrolled 2D facial images.	OpenCV (uses HOG features and linear SVM classifier); CNN (Deep et al.)	The results indicate that using CNNs as a feature extractor is the most suitable deep transfer learning approach for small datasets.
Khan et al. [56]	To simultaneously segment and track cell instances in 3D volumetric video sequences.	Voxel-Embed Algorithm; GPU with 12GB of memory; 3D datasets	The proposed approach consistently outperforms existing methods on two extensively annotated datasets, showcasing its versatility and efficient memory use.
Perminov et al. [57]	To enhance the object detection model's resilience to varying weather conditions and incomplete training data.	Image-to-Image-translation methods, policy enhancements, and Automatic White Balance	Results show that AWB was not as effective as the other two techniques. The paper suggests that a combination of the policy augmentation and I2IT techniques was a better-performing model.
Wilkinson et al. [58]	Development of a die edge detecting algorithm for quality assurance of silicon wafers.	Comparative analysis of Otsu, Canny, LoG, DoG, and RG segmentation techniques	The results present that the Otsu algorithm is the most effective of the five.
Senthilkumar et al. [59]	An attempt to beat the cost and still maintain efficiency in obtaining high-frequency, continuous pictures of the forest canopy, and obtaining high-frequency, lengthy pictures of the woodland canopy	Open-source R script for post-processing, Raspberry Pi	The system was discovered to be cheap and easily adaptable.
Xu et al. [60]	Develop an image-capturing and recognition algorithm and validate the use of Raspberry Pi as a processing module for such a task.	Eigenfaces methodology. Raspberry Pi.	Experimental results reveal that the entire image processing is fast enough with the Raspberry Pi. Between the Raspberry Pi board and the camera, the data transfer can move fluidly.
Gul et al. [61]	Develop an enhancement method for low-light images.	Frequency-based decomposition using a novel network.	The suggested technique has drawbacks, such as the possibility of failure in situations with small items and the inability to extract crucial contextual information from surrounding locations to retrieve the contents.
Vite-Chávez et al. [62]	Creates a light improvement task by estimating curves specific to an image.	A Zero-Reference novel method of Deep Curve Approximation.	The findings show that the new method is efficient and generalises well to diverse lighting conditions despite its simplicity.
Fayomi et al. [63]	Applying the Otsu approach to improve binary segmentation for the classification and detection of fruits.	Otsu method	It was realised that an improvement was achieved when a blue station of the RGB rest images was used due to its advanced contrast.

5. Discussion of the Challenges and Future Trends

Developing an automated marks collation system entails overcoming several formidable challenges. Firstly, the absence of standardised data formats in educational data management presents a significant obstacle [64, 65]. Integrating data across systems without uniformity becomes cumbersome, potentially leading to inaccuracies and duplicates in the collation process [66].

Secondly, the high costs of implementing advanced robotic systems pose a barrier. Beyond the financial investment, training educators to utilise these technologies effectively adds another layer of complexity, demanding resources and time [67]. Moreover, image processing difficulties further complicate the development of an automated marks organisation system. Defining "meaningful regions" within images and accurately representing objects remains intricate, especially in automated grade recording. These challenges highlight the need for sophisticated algorithms to process and interpret visual data [68] accurately.

On the brighter side, educational robotics and AI integration advancements offer promising solutions. As educational robotics revolutionises learning experiences by equipping students with essential skills, integrating AI technologies can enhance the automation and efficiency of mark collation systems [69]. Deep learning techniques, particularly entity relation extraction, demonstrate superior performance compared to traditional methods. Leveraging these advancements can streamline the collation process and improve accuracy by extracting intricate features from various data sources, including student comments. This process will enhance the educational sector for high-level performance in the student evaluation process. Also, the effective collaborations of researchers in mechanical and mechatronics engineering will assist in bridging the gap of many difficulties to achieve the primary purpose of sustainable development goals in education [70].

5.1. Discussion on the Proposed Robot Arm and AI System for Administrative Optimisation and Sustainability

The 3D modelling of the robot arm (proposed structural architecture to sit the web application on the robot arm, as shown in Figure 9 is an Revolute-Revolute-Revolute (RRR) configuration that was completely modelled using the SolidWorks Software, and it consists of three links and an end effector. The first link, extending from the base, is 169.70 mm long, followed by a second link of 260 mm and a third link of 76.09 mm in length. The end effector, a suction cup, has a length of 12.42 mm. The base has a height of 56mm and a diameter of 50mm. At full stretch to the top, the arm reaches a height of approximately 506.21mm, comparable to the height of a standard two-liter soda bottle. The complete design of the model, its dimensions, and labeling are shown in the results chapter [71].

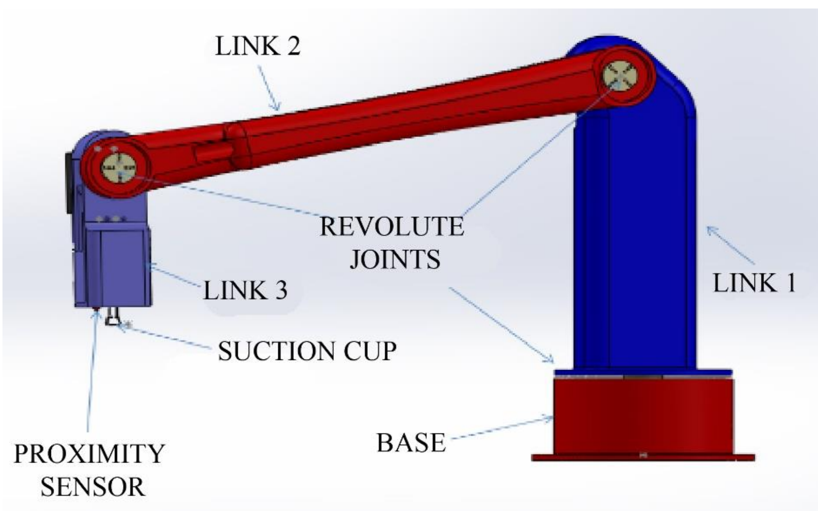
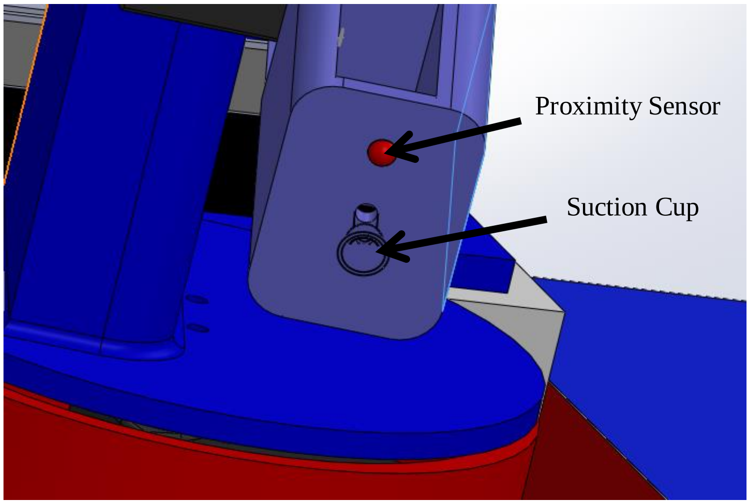


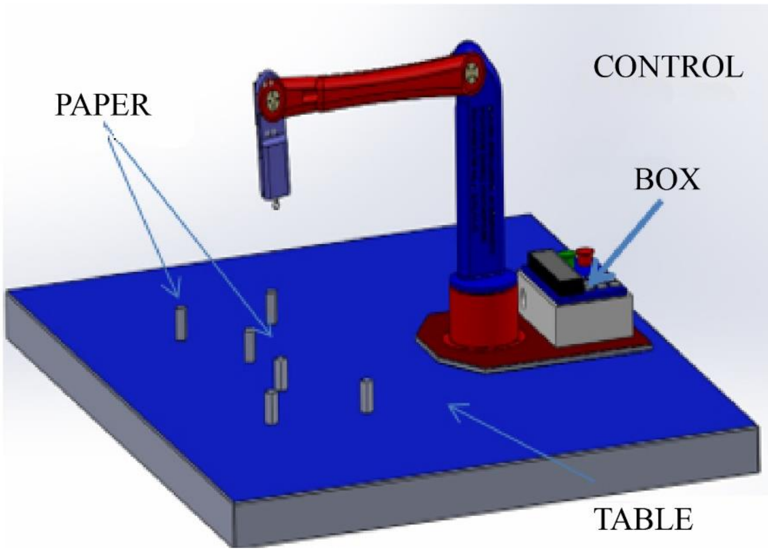
Fig. 9 Overview of the robot arm assembly

5.1.1. Functionality Overview and Component Design

The student scripts were meant to be picked up and carried by the arm. The suction cup end effector is utilised to pick up the script by creating and removing a vacuum. The third link proposes that a camera be installed to photograph the script before one picks it. To accommodate a variety of stack heights, a proximity sensor ensures the arm moves only when it is close to the script stack. It is recommended to make use of servo motors to move the arm in order to control it accurately and specifically. Arm operation: Your arm's camera, proximity sensor, and end effector are its three main working components. The suction cup end effector was custom-built to ensure the script had a strong grip so that it would be picked up and placed accurately. The script pile is sensed by the inductive sensor, so that the arm will only work when necessary. The camera enhances the arm's ability to read scripts by taking pictures, which are then processed further. A detailed analysis of the suction cup and proximity sensor design is given in section 6.5 [72]. In this article, we will suggest that the working space of the arm robot is a part with a 254.43 mm length and 252.96 mm width, the base of the arm. A control box 34, which is 117.4 mm long and 171.08 mm wide, including a keyboard and display for operation, is mounted on top of it. This assembly (together with the cable) is laid on an 800 mm long and 1000 mm wide table. The table is itself held together by six small cuboids that maintain the stack of scripts: three holding unmarked and another three supporting marked scripts. The integrated design is that which includes all functional features necessary for effective operation of it, among which are the suction end effector and the proximity sensors. In addition, the end effector and proximity sensor are shown in Figure 10 to provide a more detailed picture of their application in the system. Finally, Figure 11 depicts the operational environment of the robot arm, which was designed and visualised in SolidWorks with attention to detail in a manner that has defined its working field.



(a)



(b)

Fig. 10 (a)A closer look at the proximity sensor and suction cup, and (b) Detailed illustration of the robot arm working environment.

5.1.2. Web Application Backend Development Project Structure

In accordance with best practices for Flask applications, the project structure for creating the web application (as shown in Figure 11) is designed to ensure maintainability and clarity. The Flask app is instantiated, and configurations are defined at the root level in main. Py, the application's entry point. The core components of the application reside in app/. Here, init initializes the Flask application in this directory. Py and also creates any necessary extensions and configurations.

User authentication, like register, logout, and login features, is handled by auth. Py file [73]. The edges and endpoints of the app are defined in routes. A Python file, which also handles user inputs and returns appropriate replies. A model for a database is represented in Django by a Python class that subclasses django.db.models.Model. The information about the layout of the fields in a table and their types is specified with the attribute definition of each field. Py. The dynamic/ directory: it has the CSS, JS, and images. The blueprints/: that is where all those HTML templates (rendered by Flask views) reside. The application is simple to use, develop, and maintain thanks to its well-organised structure, which enables a clear division of responsibilities. The summary analysis of the proposed system describes the development of an automated system for recording and collating marked examination scripts in educational settings. The study focused on three primary objectives. First, a data extraction pipeline was developed, employing ORB feature detection for image alignment and adaptive thresholding to handle lighting variations, capturing student information and marks from custom scripts captured with a camera. Second, character recognition models were designed using Single Input Convolution Neural Networks (SICNN) with different image pre-processing techniques-binarisation, thinning, and gradient magnitude calculation-and trained on the 'EMNIST by_merge' dataset, focusing on recognising matric numbers from the engineering faculty and custom scripts written by four different students [74]. Third, a structural framework for the image processing and recognition system was simulated using SolidWorks, featuring a robot arm equipped with a suction cup and a camera as the end effector. Performance testing was conducted using MATLAB's multibody system application.

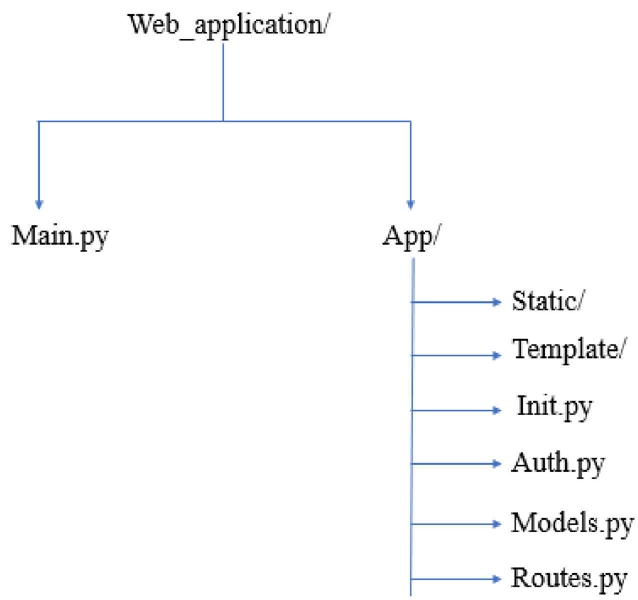


Fig. 11 Diagrammatic representation of the web application project structure

6. Conclusion

This work presents a masterful overview of the fundamental requirements for designing an advanced computer-based student mark database system, aiming to enhance the educational economy for sustainable education. The analyses of reviewing mechanisms for educational data administration, such as automation systems, robotics and automation in education, and image processing technologies for grade recording and data extraction for student information retrieval, are paving the way for future creative development in educational management.

i. Using programme title: 4 Quality education-meta-aria-title: AI and robotics solutions for administrative optimisation-programme-desc-methods-pyramids-and-studysettings-summary-intermediate-html-tud-topic-specific-word: with all the programs analyzed, this essay focuses on SDG 4 quality of education-tud-topic-significance-word: Through OutcomesFrom AI and Robotics-Based Solutions for Administrative Optimizatiton, The Survey Paper has been targeted directly to the SDG 4, i.e., Quality Education.
ii. There are also knock-on impacts for the other SDGs, and particularly with regard to owners, Action acceleration, and 17 Partnerships – with technology giving us a chance to transform our age-old ways of how we work now, allowing educators time to think about strategic planning and profound challenges.
iii. Hybridisations: The paradigm may also be hybridised with the help of MLaiRobotic in a way that further improves maintenance of an educational system.

6.1. Recommendation

Based on the key conclusions drawn, the study offers the following recommendations.

1. The study recommends that further work be done on the functionality that can extract and recognise the details of the students atop their scripts. This has been implemented, and the physical construction can be developed by following through with the design presented in this work.
2. The study will also recommend implementing the adaptive threshold technique over the Otsu threshold technique for binarizing images, as it provides more precise and more accurate text extraction when it calculates thresholds for smaller regions of the image.
3. Optimising data extraction accuracy by improving the data extraction pipeline to ensure high correctness and reliability for feeding character recognition models.
4. I finally recommend that more work be done in looking at methods that could help extract data from custom scripts. However, this is not easy, given that being custom allows significant variations.

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