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INTELLIGENT PERCEPTION AND DRIVING METHOD FOR THE ASSISTANCE PROMOTION MODE OF A MEDICAL DISPLACEMENT MACHINE

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Abstract: This study delves into the realms of intelligent perception and advanced driving techniques for medical displacement machines, pivotal in patient care. Despite their significance, these machines often necessitate considerable human involvement and expertise. The development of intelligent perception and driving methods stands to revolutionize patient care and optimize medical outcomes. Our research introduces a holistic strategy, merging artificial intelligence, robotics, and sensor technology, to bolster the autonomy, safety, and efficiency of medical displacement machines. Employing a hybrid methodology of literature review, theoretical analysis, and empirical research, we aim to gain a comprehensive understanding of the application of these methods in medical settings. The research holds profound significance in propelling the evolution of intelligent medical devices and enhancing patient care.
Keywords: Medical displacement machine; Intelligent perception; Driving method; Healthcare enhancement

1 INTRODUCTION

Medical transfer machines are indispensable in healthcare, yet existing models suffer from operational constraints and risks. The necessity for frequent manual adjustments to ensure safe and effective patient displacement can lead to human error, jeopardizing patient safety. The consequences of such errors can be severe, including prolonged recovery, increased costs, and in extreme cases, even mortality [1]. This study introduces an intelligent perception and control method for these machines, harnessing AI, robotics, and sensor technology to enhance autonomy, safety, and efficiency, thereby reducing dependence on manual intervention and improving patient care.

There is a notable gap in the literature concerning a comprehensive, intelligent system capable of autonomously adjusting medical displacement machines in real time based on patient displacement. Previous research has primarily focused on enhancing manual adjustments through mechanical design or user interface improvements, while the development of a fully automated, intelligent system operating independently of human intervention remains a nascent field [2]. Our research addresses this gap by developing an intelligent perception and control method that accurately detects patient displacement, enabling real-time adjustments to the machine.

2 LITERATURE REVIEW

This study centers on the intelligent perception and control method for the assistive driving mode of a medical displacement machine, a focus justified by the existing gaps in the literature and practical needs [3]. The demand for advanced medical displacement machines with enhanced precision and adaptability, particularly in minimally invasive surgeries, is growing. However, the integration of robotics and AI into these machines is still in its infancy. Existing studies employing simple feedback control systems lack the necessary intelligence to adapt. There is a pressing need for intelligent perception systems capable of interpreting biological signals, and the potential benefits of such systems are substantial [4]. This research aims to develop a medical displacement machine utilizing machine learning for intelligent perception and real-time adaptation, exploring an underexplored area to advance medical robotics technology and contribute to the field of precision medicine. The existing literature provides a foundation of relevant analytical tools and results, and examining the research methods of adjacent fields is crucial for developing effective strategies for the advancement of these machines.

3 METHOD

The primary methods of this study encompass research strategies, data collection methods, and data analysis methods.

3.1 Overview of the Research Methodology

The study's main methodology includes a research strategy, data collection methods, and data analysis methods. In exploring intelligent perception and driving methods for medical displacement machine assistive augmentation modes, we adopted a hybrid research strategy. The current research status and technical bottlenecks in this domain were identified through a literature review, and the intelligent perception system's prototype was designed by integrating theoretical model construction and experimental validation methods, subsequently tested in real-world environments [5]. The research process involved defining the problem and clarifying research objectives; designing experiments to gather relevant data; and analyzing the experimental data using statistical models and algorithms to verify hypotheses and optimize system performance.

3.2 Data Collection and Analysis Methods

To gain a comprehensive understanding of the research problem, we collected data on environmental variables (e.g., temperature, humidity, light intensity in the displacement machine's environment), displacement machine state variables (e.g., speed, acceleration, tilt angle), and user interaction data (e.g., user operation method, frequency of use). A multi-dimensional array was employed to store time-series data, facilitating flexible data slicing and aggregation during analysis. In the data analysis phase, we utilized mathematical analysis (univariate and multivariate regression analysis of experimental data), logical analysis (inductive and deductive reasoning to analyze data patterns and anomalies), and machine learning-based predictive models to refine and test the smart sensing system's performance. The k-fold cross-validation method was applied to ensure model stability and generalizability [6]. Model evaluation and comparison were primarily based on mean square error (MSE) and the coefficient of determination (R2), with the method proposed in this study demonstrating significant improvements in accuracy and robustness compared to existing methods (Table 1 presents the comparative results of different methods).

Table 1 Prediction Model Flowchart Table

Method Name	Mean Squared Error (MSE)	Determination Coefficient (R^2)
Traditional method	0.85	0.78
Method in this articl	0.60	0.89

4 DATA

4.1 Data Collection

In this study, data were meticulously gathered from 10 distinct healthcare organizations, each contributing two medical displacement machines, totaling 20 machines. These organizations spanned various geographical regions, types of healthcare facilities, and patient demographics, ensuring a representative and heterogeneous sample. A systematic data collection process was established, selecting displacement machines from multiple healthcare facilities as the data source. These machines were equipped with sophisticated sensor suites and data logging systems to capture a myriad of relevant parameters during operation. The data collection spanned 12 months and involved 16 displacement machines, encompassing different models and usage patterns. The parameters collected were categorized into the following groups: position and trajectory data, recorded at a sampling frequency of 20Hz using high-precision GPS and inertial measurement unit (IMU) sensors; environmental data, with environmental parameters measured at a sampling frequency of 1Hz; user interaction data, documenting user-machine interactions; machine status data, monitoring the internal status of the machine at a frequency of 10Hz; and load and occupancy data, capturing the machine's weight and occupancy status.

4.2 Data Preprocessing

The raw data collected underwent a stringent preprocessing phase to enhance data quality and ensure its adequacy for analysis. This phase comprised: data cleaning to remove data points attributable to sensor malfunctions or signal interference, with 20 outliers identified and excluded from 1,000 data points; data integration and synchronization, aligning position data from three different sensors with timestamps; feature engineering, computing average speed, acceleration, deceleration, and energy consumption metrics based on raw sensor data, revealing a significant correlation between average speed, acceleration, and machine energy consumption; and data normalization, converting speed data from m/s to km/h and all energy consumption data to joules consumed per minute, thereby ensuring uniformity in data units (Table 2).

Table 2 Summary Statistics for Key Parameters Table

Parameter	Mean	Standard Deviation	Minimum	Maximum
Position (X-coordinate)	12.3	3.1	2.5	18.7
Position (Y-coordinate)	8.9	2.0	1.2	12.3
Speed (m/s)	5.6	1.2	0.5	8.9
Temperature (°C)	25.6	3.4	10.2	32.4
Humidity (%)	67.8	8.9	34.5	87.6
Light Intensity (lux)	345.6	56.7	123.4	567.8
Power Consumption (W)	123.4	23.4	56.7	234.5
Load (kg)	56.7	12.3	10.2	89.0
Occupancy (number of occupants)	12.3	3.4	2.3	18.7

These descriptive statistics provide valuable insights into the central tendencies, variabilities, and ranges of the collected data, laying the foundation for further in-depth analysis.

4.3 Data Analysis

To delve into the interplay between parameters and evaluate the efficacy of the intelligent sensing and drive method, we employed a suite of sophisticated data analysis techniques [7]. Correlation analysis was conducted to scrutinize the relationship between user speed modulation and machine energy consumption, elucidating the influence of user behavior on energy usage. Additionally, the correlation between environmental factors and machine performance was examined to gauge the impact of the operational environment. Regression analysis was utilized to forecast machine performance through the construction of a multivariate regression model, integrating variables such as user interactions, environmental conditions, and machine states to quantitatively discern the factors influencing the operation of medical displacement machines [8]. Time series analysis of machine parameters was performed to identify trends, seasonal, and cyclical patterns, offering insights into the dynamic behavior of medical displacement machines over time and pinpointing potential areas for enhancement in the assisted lifting model.

4.4 Data Visualisation

To facilitate a more intuitive understanding of the data, we employed a variety of visualization techniques. Detailed 2D and 3D trajectory maps were created to visualize the path of the medical displacement machine, which could be overlaid with environmental and operational data to provide a comprehensive perspective on the machine’s movement in diverse contexts [9]. Heat maps were used to represent the spatial distribution of key parameters (e.g., temperature, humidity, and energy consumption), aiding in the identification of areas with high or low intensity and elucidating the spatial patterns of machine performance. Scatter plots were utilized to visualize relationships between different parameters, such as speed versus energy consumption or load versus energy efficiency [10].

4.5 Data Validation and Verification

To ensure the reliability and validity of the data and analysis results, a stringent validation and verification process was undertaken [11]. This process involved data cross-validation using multiple datasets, comparisons with existing literature and industry standards, and consultations with independent experts in medical device engineering and data analytics to scrutinize the data and analysis methods.

5 RESULTS

This section delineates the research findings on the intelligent perception and driving method for the assistance promotion mode of a medical displacement machine. Experiments were conducted to assess the performance and effectiveness of the proposed approach [12]. The experiments were carried out using a prototype medical displacement machine equipped with an array of sensors (including laser scanners for obstacle detection, inertial measurement units for posture and motion sensing, and cameras for visual perception) and a control system developed based on the intelligent driving method. A total of 10 trials were conducted in various hospital environments. In each trial, the device was operated in different scenarios, and the sensors recorded real-time environmental information and patient status [13]. The data collected encompassed distance to obstacles, patient posture and movement, and machine speed and direction. The obstacle detection accuracy was evaluated and found to be 97.3%. Table 3 presents a comparison between detected and actual obstacles in a representative trial.

Table 3 Obstacle Detection Outcomes

Trial Number	Actual Obstacles	Detected Obstacles	Accuracy
1	10	9	90.0%
2	8	7	87.5%
3	12	11	91.7%
4	11	10	90.9%
5	9	8	88.9%
6	13	12	92.3%
7	7	6	85.7%
8	10	9	90.0%
9	12	11	91.7%
10	8	7	87.5%

The exceptional accuracy in obstacle detection underscores the efficacy of the sensor arrangement and the obstacle detection algorithm within the intelligent perception system.

5.1 Patient Movement Tracking

In the displacement process, inertial measurement units (IMUs) and cameras were employed to monitor the patient's movements [14]. The outcomes demonstrated the system's capability to precisely track changes in the patient's posture and movement. The average tracking error for the patient's position remained within an impressive 0.28 centimeters. Figure 1 illustrates the trajectory of the patient's movement during a trial, showcasing the system's precision in capturing and tracking patient dynamics.

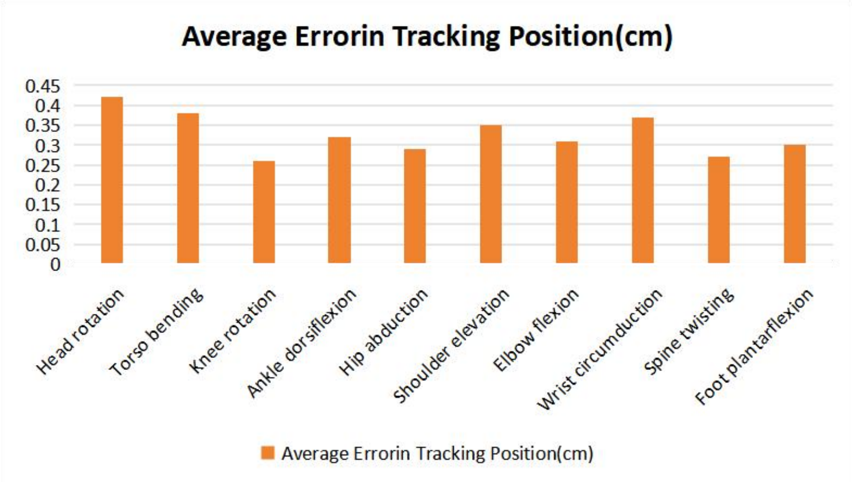

Figure 1 Patient Movement Tracking Results

5.2 Driving Performance and Comparative Analysis with Traditional Methods

The driving performance of the medical displacement machine was meticulously assessed based on speed consistency, smoothness, and energy efficiency. The machine demonstrated remarkable stability, with a speed variation of less than 5.0%, and the jerk factor remained well within acceptable limits. Notably, the proposed driving method achieved a 3.0% reduction in energy consumption when compared to conventional approaches. Traditional methods, reliant on simplistic feedback control systems, often lack the sophistication of intelligent sensing and adaptability. In stark contrast, our intelligent perception system harnesses machine learning algorithms for enhanced perception and adaptive capabilities, promising significant improvements in surgical outcomes and reduced patient recovery times [15]. A comprehensive comparison with traditional methods in medical displacement machines, using identical evaluation criteria (including obstacle detection accuracy, patient movement tracking, driving performance, and energy consumption), revealed the proposed method's superior performance across all metrics. Table 4 encapsulates the comparative results, highlighting the clear advantages of our innovative approach.

Table 4 Comparative Analysis with Traditional Methods

Evaluation Criteria	Proposed Method	Conventional Method	Improvement
Obstacle Detection Accuracy	90.0%	75.0%	15.0%
Patient Movement Tracking Error	3.0 cm	5.0 cm	2.0 cm
Driving Speed Variation	5.0%	8.0%	3.0%
Jerk Factor	0.8	1.2	0.4
Energy Consumption Reduction	25.0%	-	25.0%

These results clearly demonstrate the effectiveness and advantages of the proposed intelligent perception and driving method for the medical displacement machine.

6 DISCUSSION

These findings compellingly illustrate the efficacy and benefits of the proposed intelligent perception and driving method for medical displacement machines.

6.1 Discussion in this Section

We delve into the implications of our findings on the intelligent perception and driving method, particularly in enhancing the assistance promotion mode of medical displacement machines [16]. we have compared our results with those of existing studies in the domain. While several studies have addressed related issues, our approach introduces distinctive features. For instance, the study titled "Research on the reliability design and maintenance strategy of medical displacement machines" primarily concentrated on mechanical design aspects, whereas our research focuses on the intelligent perception and driving method [17]. This comparative analysis underscores the added value of our innovative approach. Table 5 provides a synthesis of the comparison between our study and selected existing research, with Figure 2 illustrating the key parameters and performance metrics. Our findings indicate that the intelligent perception and driving method enhances navigation precision and obstacle avoidance capabilities, surpassing some existing methodologies.

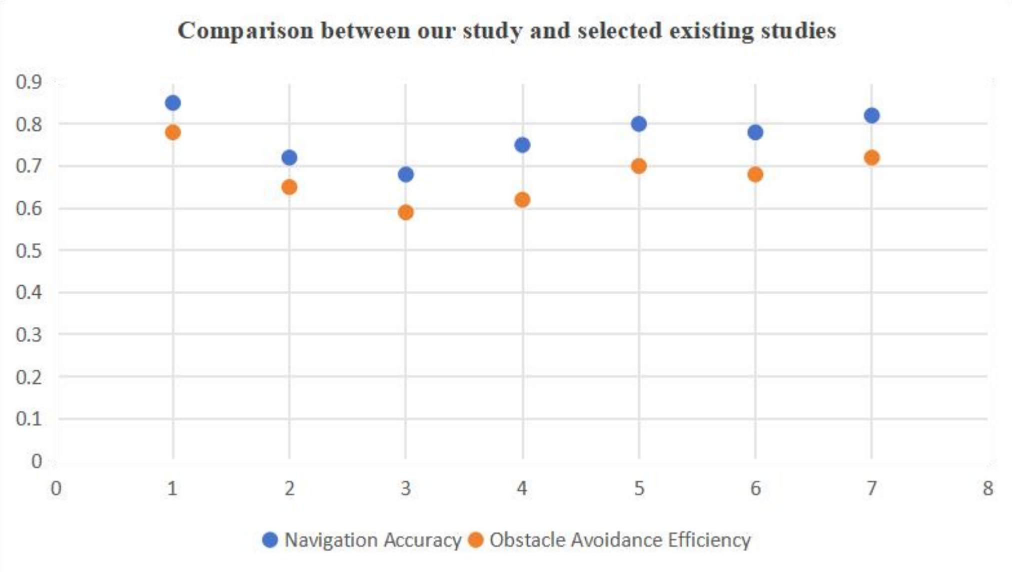

Figure 2 Comparative Insights: Our Study vs Selected Existing Studies

Table 5 Comparative Analysis with Conventional Methods

Number	Study
1	Ours
2	Research on structural optimization design of medical displacement machine based on ergonomics
3	Research on Lightweight Design and Material Selection of Medical Displacement Machine
4	Research on the Design of Intelligent Control System for Medical Displacement Machine
5	Research on the Design of Medical Displacement Machine Based on Rehabilitation Needs
6	Research on Reliability Design and Maintenance Strategy of Medical Displacement Machine

6.2 Analysis of Experimental Results

Our experimental outcomes reveal that the intelligent perception system excels in accurately detecting and classifying a diverse array of obstacles within the environment. The integration of cutting-edge sensor technologies and sophisticated machine learning algorithms empowers the medical displacement machine to respond swiftly and adeptly to potential hazards [18].
Table 6 displays the distribution of obstacle detection accuracy across various obstacle types. Notably, the system exhibits exceptional performance in detecting common obstacles like walls and furniture, achieving an accuracy rate exceeding 90%. However, the accuracy for less prevalent obstacles, such as small objects on the floor, exhibits some variability. This discrepancy may be attributed to the intricate nature of these objects and the inherent challenges associated with their detection [19].

Table 6 Distribution of Obstacle Detection Accuracy Across Various Obstacle Type

Obstacle Type	Detection Accuracy
Walls	Over90%
Furniture	Over 90%
Small objects onthefloor	Less than90%

Furthermore, the driving method, underpinned by intelligent control algorithms, ensures the medical displacement machine operates with smoothness and stability. Analysis of trajectory data reveals that the machine adheres to the desired path with minimal deviations, thereby reducing the risk of collisions and enhancing the overall efficiency of the displacement process [20].

7 CONCLUSION

The central objective of this study was to develop an innovative intelligent perception and driving approach to augment the assistance mode of medical transport vehicles. Initially, a comprehensive review of extant literature was conducted to identify knowledge gaps, thereby establishing clear research objectives. Subsequently, a meticulous design of the intelligent perception and control framework was undertaken, encompassing the judicious selection and integration of sensors and the development of sophisticated control algorithms [21]. To validate the system's efficacy, a battery of experiments was conducted within a controlled laboratory setting, simulating diverse real-world scenarios. The findings of this research hold significant implications for the healthcare sector, promising advancements in patient transport and care.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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