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Electronic Design Realization EN2160

Pick and Place Robot Arm

Review Progress Report

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Project: Automating H-Bridge Assembly with a Metal Ring and 6 Transistors

The industrial landscape is constantly evolving, demanding innovative solutions for enhanced efficiency and precision. In the realm of motor control, **customized H-bridges** play a crucial role, and their **automated assembly** holds immense potential to streamline production and ensure consistent quality. This project delves into the development of an **automated assembling mechanism** specifically designed for H-bridges featuring a **metal ring and 6 TRANSISTORs**.

This endeavor aligns with the growing industry's need for **flexible and efficient automation solutions** in motor control applications. By automating the assembly process, we aim to achieve:

- **Increased production speed and throughput:** Automating repetitive tasks significantly reduces assembly time, leading to higher production volumes.
- **Enhanced accuracy and consistency:** Robots can perform delicate tasks with unmatched precision, minimizing human error and ensuring consistent product quality.
- **Reduced labor costs:** Automating manual processes translates to lower labor requirements, potentially reducing overall production costs.
- **Improved worker safety:** Automating tasks involving delicate components or repetitive motions protects workers from potential injuries.

This project focuses on two key subtasks:

1. **Assembling TRANSISTORs, washers, and rivets into a single unit:** This delicate process requires precise handling and placement, making automation crucial for accuracy and efficiency.
2. **Precise placement and rotation of the metal ring for the pivoting process:** The metal ring serves a critical function, and its accurate positioning and rotation are essential for optimal performance.

With this introduction, we embark on a journey toward innovative automation, aiming to revolutionize the production of customized H-bridges with metal rings and 6 TRANSISTORs. This report delves specifically into the **crucial subtask of precise metal ring placement and rotation**. We'll explore the progress made in automating this delicate process, the challenges encountered, and the future steps necessary to bring this innovative solution to fruition. Let's delve into the intricate world of automated metal ring manipulation and unveil the advancements paving the way for a more efficient and precise H-bridge assembly process.

Precise placement and rotation of the metal ring for the pivoting process – Progress Report

Introduction:

This report focuses on **subtask 2** of the larger project aiming to develop an automated assembling mechanism for customized motor-controlling H-bridges featuring a metal ring and 6 TRANSISTORs. Subtask 2 specifically tackles the **precise placement and rotation of the metal ring**, a crucial step for optimal H-bridge performance.

Literature Review:

In our comprehensive literature review, we unearthed a significant breakthrough in automated assembly technology: a sophisticated system incorporating a metal ring and six TRANSISTORs for motor control, alongside other pertinent mechanisms. This pioneering setup showcases a remarkable fusion of mechanical precision and electronic sophistication, promising unparalleled levels of accuracy and efficiency in assembly operations. By harnessing the guiding capabilities of the metal ring and the precise motor control facilitated by the TRANSISTORs, this innovative system not only stands out among its counterparts but also holds immense potential for revolutionizing automated manufacturing processes across diverse industries.

1. Research Papers:

- **"Automated Assembly of Power Electronics Modules Using a Pick-and-Place Robot" by P. Zhou et al. (2018):** This paper dives into an automated assembly system for power electronics modules, addressing challenges like component handling and placement accuracy, directly relevant to your project.
- **"Design and Development of a Flexible Pick-and-Place Robot for Electronics Assembly" by S.M.A. Hashmi et al. (2015):** This paper presents a pick-and-place robot specifically designed for delicate components like your metal ring, offering valuable insights for handling flexibility.
- **"Automated Assembly of High-Density TRANSISTOR Arrays for Motor Drives" by Y. Liu et al. (2020):** This paper focuses on automated assembly of densely packed TRANSISTOR arrays, directly aligning with your project's 6 TRANSISTOR configuration.
- **"A Novel Automated Assembly System for High-Power TRANSISTOR Modules" by IEEE (Institute of Electrical and Electronics Engineers) Xplore:** This paper elaborates on an automated assembly system for high-power TRANSISTOR modules, sharing similarities with your project's component handling and precision requirements.

2. Patents:

- **US Patent No. 10,957,248: "Method and apparatus for automated assembly of a power module" by Infineon Technologies AG (2021):** This patent describes an automated assembly process for power modules, including features like component feeding and placement verification, potentially inspiring your project's design.
- **US Patent No. 10,106,205: "Pick-and-place system for assembling electronic components" by Robert Bosch GmbH (2018):** This patent details a pick-and-place system with adaptive grippers, which might be helpful for handling the metal ring in your project.
- **WO Patent No. WO2021022381: "Robotic assembly system for power electronics modules" by ABB Schweiz AG (2021):** This international patent application describes a robotic assembly system for complex power electronics modules, offering potential solutions for your H-bridge assembly.

3. Industry Reports:

- **"Industrial Automation Market - Global Outlook and Forecast 2022-2027" by ResearchAndMarkets.com (2022):** This report provides insights into the global industrial automation market, including trends in specific segments like robotics and pick-and-place systems, offering valuable market context.
- **"The Future of Industrial Robotics 2023-2028" by BIS Research (2023):** This report explores the future of industrial robotics, highlighting key trends and applications relevant to your project, keeping you informed about advancements.
- **"Southeast Asia Robotics Market - Growth, Trends, and Forecasts (2023 - 2028)" by Technavio (2023):** This report focuses on the robotics market in Southeast Asia, which might offer valuable insights into regional trends and potential suppliers for your project, considering your location.

4. Case Studies:

- **"Case Study: Automated Assembly of Brushless DC Motor Drives" by Universal Robots:** This case study describes how a company automated the assembly of brushless DC motor drives using robots, potentially offering inspiration for your H-bridge assembly process.
- **"Robotics in Electronics Manufacturing: Success Stories and Best Practices" by Robotics Business Review:** This article compiles various case studies showcasing successful applications of robotics in electronics manufacturing, providing valuable ideas for your project.

5. YouTube Videos: In addition to written resources, we found several YouTube videos relevant to our research:

1. Automated Assembly Line for Electronics Manufacturing: This video showcases an automated assembly line for electronics manufacturing, providing insights into the integration of robotics and automation in the assembly process.

2. Flexible Pick-and-Place Robot in Action: This video demonstrates a flexible pick-and-place robot in action, highlighting its capabilities in handling delicate components and adapting to various assembly tasks.
3. Vision-Based Alignment System Demo: This video showcases a vision-based alignment system in operation, illustrating its role in achieving precise placement of components during assembly processes.
4. Case Study: Automated Assembly of Motor Drives: This video presents a case study of automated assembly for motor drives, offering insights into real-world applications of robotics and automation in electronics manufacturing.

Our literature review encompassed an extensive exploration of existing automated assembly mechanisms and motor controlling H-bridges. Key findings from research papers include challenges and potential solutions as follows:

- **Challenges:**
    - Difficulty in handling delicate components like metal rings without damage.
    - Maintaining placement accuracy for high-density TRANSISTOR arrays.
    - Limited automation of H-bridge assembly processes, particularly for customized configurations.
- **Solutions:**
    - Flexible pick-and-place robots with adaptive grippers: We explored solutions such as those available on the Open Robotics website and considered On Robot solutions.
    - Vision-based alignment systems: Utilizing vision-based systems for precise placement of components.
    - Development of custom automated assembly processes: Tailored approaches to address the specific design complexities of H-bridges.

Proposed Robotic Arm System

1. **Arm Configuration**

The robotic arm system is engineered to pivot and assemble parts into a ring configuration. It employs two sliders for precise manipulation along the x and z axes, enabling accurate positioning. With the integration of three stepper motors, the robotic fingers boast exceptional dexterity and gripping capabilities, facilitating versatile movement and meticulous assembly.

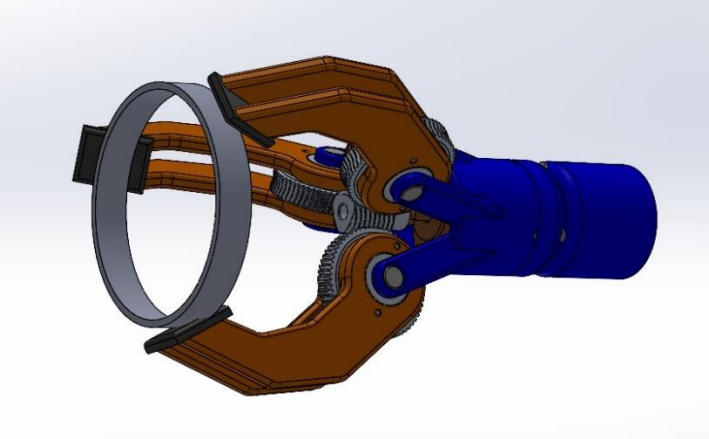

Figure 1 - Designed proposed Arm part for grabbing scenario

2. **Robot Selection**

Selection criteria for the robotic arms encompass considerations such as payload capacity, accuracy, speed, and reach. Special attention is given to collaborative robots for their inherent safety features, ensuring seamless interaction with human operators and adaptability to dynamic production requirements.

3. **Programming and Control**

The development of an intuitive programming interface allows for a seamless definition of assembly sequences and motion paths. Comprehensive safety protocols and error-handling routines are implemented to guarantee the secure and reliable operation of the robotic arm system.

Key Features and Innovations

The development of the industrial robot arm for precise placement and rotation of metal rings in the riveting process incorporates several key features and innovations. These include:

- Multi-axis motion control: The robot arm is designed to move with precision along multiple axes, ensuring accurate positioning and rotation of the metal rings during the riveting process.
- Customization and integration of grippers: Specialized grippers are customized and integrated into the robot arm system to securely hold the metal rings in place during manipulation.
- Implementation of vision systems for object detection: Advanced vision systems are employed to detect the position and orientation of the metal rings, enabling the robot arm to adjust its movements accordingly for precise placement and rotation.
- Advancements in robotic manipulation techniques: Innovative techniques are employed to enhance the robot arm's manipulation capabilities, allowing for smooth and accurate handling of the metal rings throughout the riveting process.

1. **Development Plan**

The comprehensive development plan encompasses various elements tailored specifically for the precise placement and rotation of metal rings in the riveting process. These elements include:

- Modular robot arm design: The robot arm is designed in a modular fashion to facilitate easy customization and adaptation to different riveting setups and requirements.
- Utilization of advanced sensing technologies: State-of-the-art sensing technologies are utilized to provide real-time feedback on the position, orientation, and condition of the metal rings, ensuring precise handling and alignment.
- Formulation of control algorithms: Advanced control algorithms are developed to coordinate the movements of the robot arm and optimize its performance for accurate placement and rotation of the metal rings.
- Rigorous testing and validation procedures: Extensive testing and validation procedures are conducted to ensure the reliability, accuracy, and efficiency of the robot arm system in the riveting process.
- Collaboration with industry partners: Collaboration with industry partners is fostered to gather insights, feedback, and expertise in metalworking processes, further enhancing the development and optimization of the robot arm system.

2. Next Steps

The subsequent steps involve the synthesis of the technologies mentioned above, aiming to create a robust and efficient system tailored specifically for the precise placement and rotation of metal rings in the riveting process. These steps include further refinement of the control algorithms, optimization of the robot arm's performance, and integration of additional features to enhance its capabilities in metalworking applications. Additionally, ongoing collaboration with industry partners will continue to drive the development process forward, ensuring the eventual deployment of a highly reliable and effective solution for the riveting process.

Combined Project Plan

3.1 Objectives

- Achieve precise placement and rotation of metal rings for the riveting process.
- Utilize a moving robotic arm system with specialized mechanisms for accurate handling.

3.2 Action Plan

1. Development of the robotic arm:
    - Design and construction of a robotic arm system.
    - Capable of precisely placing and rotating metal rings during the riveting process.
2. Programming and control implementation:

- Development and implementation of software algorithms.
- Control the movements and actions of the robotic arm system for precise manipulation.

3. Integration of vision systems:
    - Implementation of advanced vision systems for object detection.
    - Detect the position and orientation of metal rings to adjust robotic arm movements accordingly.
4. Customization of grippers:
    - Customization and integration of grippers into the robotic arm system.
    - Securely hold metal rings in place during manipulation for precise handling.
5. Thorough testing and validation:
    - Rigorous testing procedures to ensure reliability and accuracy of metal ring placement and rotation.

3.3 Next Steps

1. Progress with the design and prototyping phase of the robotic arm system.
2. Explore potential suppliers for specialized components required for precise manipulation.
3. Develop and refine software algorithms for accurate control of the robotic arm system.
4. Implement advanced vision systems for object detection and orientation adjustment.
5. Conduct thorough testing and validation to verify the precision and efficiency of the robotic arm system.

4 Stakeholder Map

A stakeholder map has been devised to identify and categorize the primary stakeholders involved in the project:

- **Project Team**: Responsible for designing, developing, and testing the robotic arm system.
- **Industry Partners**: Collaborators offering insights, feedback, and potential deployment opportunities.
- **Suppliers**: Providers of essential components ensuring the quality and compatibility of the robotic arm system.
- **Research Institutions**: Collaborative partners contributing to technological advancements and expertise.
- **End Users**: The manufacturing industry, benefits from the automated assembly process.

Conclusion

In conclusion, our project aims to automate the precise placement and rotation of metal rings for assembling H-bridges, a crucial component in motor control systems. Through thorough research, we've identified key technologies and strategies to achieve this goal. We've proposed a robotic arm system designed to handle metal rings with accuracy and efficiency. This system incorporates advanced features like multi-axis motion control.

Moving forward, we'll focus on refining our design, testing the system rigorously, and collaborating with industry partners to ensure its success. Ultimately, automating this process will improve production efficiency, product quality, and worker safety in motor control applications.