James Dyson Outreach Activity – Robot Control

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Introduction: Relevance of Robotic Control on Modern and Future Technology

Robotic control, a domain with its roots deeply embedded in history, plays a crucial role in our modern society and its future. Initially conceived as simple automated machines, robots have grown into complex systems requiring intricate control schemes. Their significance spans numerous sectors, from industrial manufacturing to healthcare and even space exploration.

In today's technological landscape, robots are no longer seen as mere automata but as intelligent systems capable of dynamic decision-making. However, there are inherent challenges within the field of robotic control, such as dealing with non-linearities, dynamic effects, and maintaining accurate control in high degrees of freedom. Researchers globally are working tirelessly to solve these challenges, employing advanced concepts such as deep learning and predictive modelling.

Proposed Activity: Robotic Drawing

Understanding how a robot controls is, in most cases, a relatively simple task. Robots are designed with a set of actuators through which input signals can be sent. Generally, these actuators can be operated manually, a key aspect in helping to understand the nature of robotic control by allowing the user to become the controller. Grasping the essence of manual operation provides invaluable insights into the objective and the challenges associated with automatizing the process, and it is this premise that forms the essence of the proposed activity.

To encapsulate this dual aspect of robotic control—manual and automated—the activity was thoughtfully designed in two parts. By doing so, the students were given the opportunity to experience first-hand the contrast and connection between the two operational paradigms.

- In the first part of the activity, the students are divided into groups and introduced to a real-life application of manual robotic control. The task involves manipulating a Universal Robots manipulator to draw a stickman on paper. The robot, known for its precise 3D actuation, has a marker physically taped to its end effector to allow it to draw on a piece of paper on the table underneath. The robot is linked to a control screen to allow for inputs to be sent manually. Here, the students have to navigate its movement in 3D space using a simple set of arrow controls. This

hands-on experience can allow them to understand the fundamental principles of robotic control and the intricacies involved when controlling a robot manually.

- The second part of the activity focuses on exploring the potential of automation in robotic control, specifically through the lens of artificial intelligence (AI). In this segment, students get to witness how a MATLAB program could allow them to draw on a digital canvas. The robot is then tasked with replicating the students' digital artwork onto physical paper. This segment of the activity serves a dual purpose - to demonstrate the integral role of AI in modern robotics and to reinforce the critical role control plays in achieving desired outcomes in robotics. Furthermore, it highlights the stark contrast between manual operation and AI-assisted automation, enabling the students to appreciate the advancements and possibilities in the field of robotic control.

My Fourth Year Project and the Activity

The insights from the proposed activity resonate strongly with the underlying principles of my project, which focuses on the dynamic control of a STIFF-FLOP soft robotic manipulator using a learning-based approach.

Soft robotics represents a fascinating dimension of robotics that mimics biological structures using compliant materials. However, the high degrees of freedom and non-linearities associated with such materials present significant challenges in terms of modelling and control. The project confronts these challenges by employing a learning-based approach, specifically leveraging the power of neural networks to predict and control the robot's motion.

The connection between the activity and the project is multi-layered. In the first part of the activity, where students draw manually with the robot, they can experience some of the key challenges of controlling robots. These challenges echo the ones confronted in the project, albeit in a more complex context, since soft robots further possess high degrees of freedom and inherent non-linearities. Furthermore, the drawing context of the activity connects indirectly to a section of my project that involves soft robotic shape matching via hand-drawn images.

In the second part of the activity, the students witness the potential of AI in automation and overcoming robotic control challenges. The role of AI, as demonstrated in the activity, is also the main element of my project. The AI in the activity is simple and deterministic, akin to early control algorithms developed at the dawn of robotics. My project, on the other hand, uses the modern approach of a neural network model to predict and optimize the dynamic motion of a soft robot.

In essence, both the project and the activity underscore the symbiotic relationship between robotics and AI. They explore how AI can aid in simplifying the complexities of robotic control, making it possible for robots to perform intricate tasks accurately. Through the activity, students are given a glimpse into this dynamic world of advanced robotics, allowing them to appreciate the potential of this fascinating field.

Activity: Results

The activity turned out to be a valuable learning experience for the students. Due to technical limitations, students were divided into two large groups. One group focused on working within the constraints of the robot, while the other pushed the boundaries, discovering how to change the robot's orientation to draw curved lines.

The manual control task made students aware of several challenges, including the limited range of robot motion, visual feedback from a narrow perspective, and inconsistencies in cartesian directions. However, during the AI-assisted drawing task, they observed how these challenges could be mitigated by leveraging the power of AI.

In terms of safety, the risk management strategy ensured a safe environment throughout the activity, with no incidents to report. All in all, the activity successfully delivered its learning objectives, underscoring the importance of robotic control and the potential of AI in overcoming its associated challenges.