PX-Alpha Operator: A Hardware Extension for KUKA Robot Realtime Controlling in Architectural Setup

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ABSTRACT

PX-Alpha Operator is a research investigation project based on an internationally filed patent by the author(s), focused on human-robot interaction and robotic control/motion in the field of design and digital fabrication. Using hardware solutions, PX-Alpha Operator enables users—with limited or no programming background, to control, design, and execute robotic motion-paths, without needing any additional software package or advanced coding knowledge. Operating as a hardware plug-in, PX-Alpha Operator—as a device, can be added to any KUKA robot with the 4th generation controller—KRC4, regardless of the robot's type and payload. Through bypassing the software components of the operation/programing, PX-Alpha Operator controls the robot by pushing the buttons on the physical controller in realtime. This method opens a wide variety of input possibilities—including any digital or analog sensors, through which the user can control the robot.

PX-Alpha Operator aims to make realtime robotic interaction more accessible to designers—especially in the field of architecture, by simplifying some of the advanced programming aspects of the process.

INTRODUCTION

Making technology more available for users without technical background in the creative disciplines has always been a critical agenda for technologists and designers. Later in the digital era, this interest started to expand the creative medium of designers/creators by introduction digitality. From some of the creative machines by engineers such as Ken Goldberg, in late 80s and early 90s, to the work of creative critical thinkers/artists such as Harold Cohen, there has been an extensive interest for using technology as a creative medium for design (Goldberg, K. 1992, and Cohen, H. 2020). Probably one of the most familiar examples in the field of visual arts and design is Processing software developed at MIT and specifically as a programming language for artists to create art (Reas, C. and Fry, B. 2007). Similarly there has been a tremendous effort in creative custom-made software platforms for native digital design environments to communicate with machines directly through design software. KUKA|Prc and HAL plugins for grasshopper, Sprant.O for MAYA and Oriole for Rhino, are some of the examples that replace the rigid robotic programming languages with native in-software scripting (Braumann, J. and Brell-Cokcan, Sanfilippo, F. et. all. 2012, S. 2015, Kruysman, B. and Proto, J. 2014, Poustinchi, E. 2019).

Although these tools and platforms are tremendously valuable to make technology more accessible for designers with limited technical background, they still depend on 1-basic programming knowledge, and 2- specific/limited digital software platforms.

METHODOLOGY

Invented at the [Hidden-for-peer-review] lab, and internationally secured under the patent cooperation treaty (PCT), PX-Alpha Operator as a project-based research is focused on three central themes:

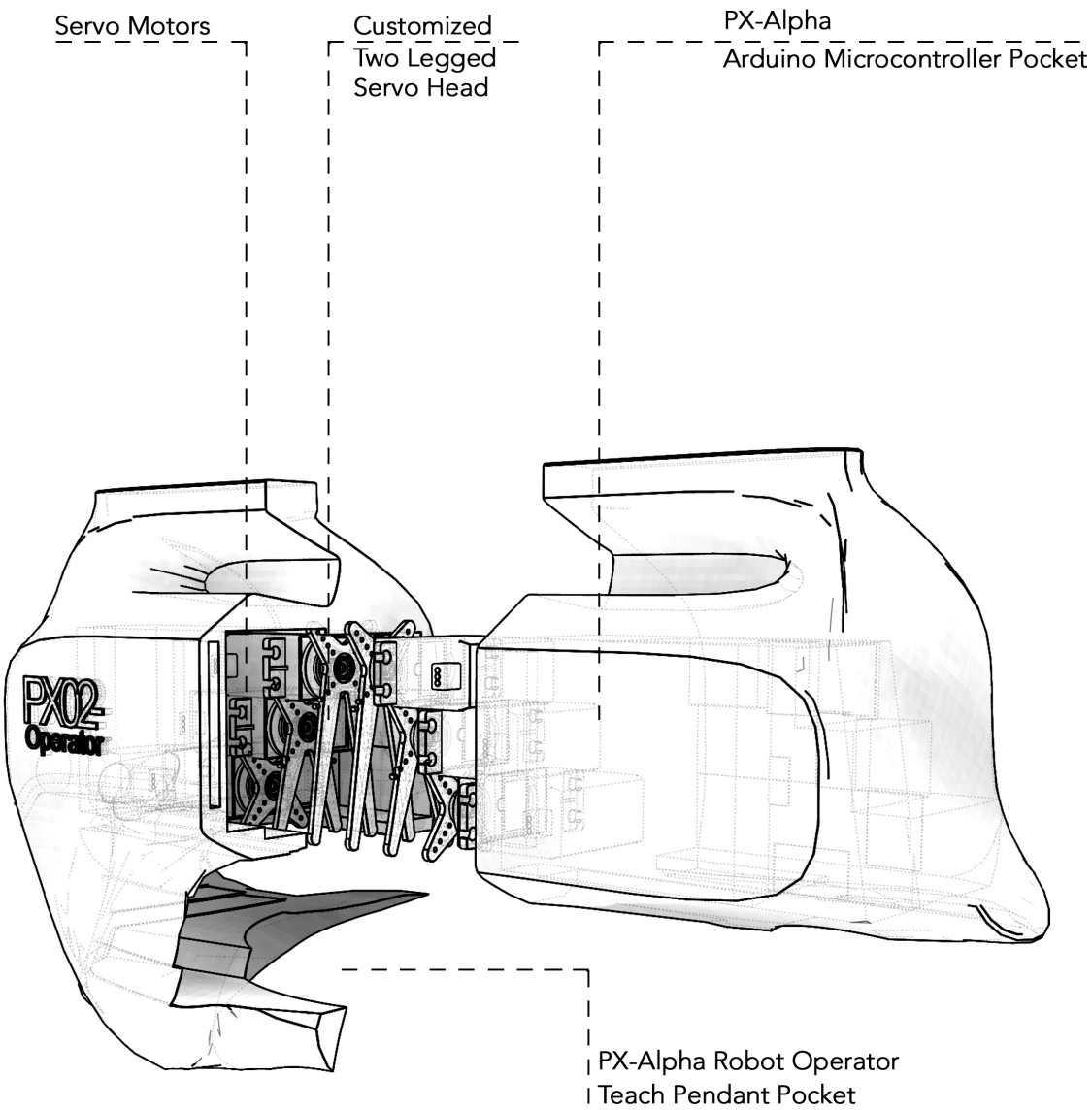
1. Examining the potentials of hardware platforms, as possibly more intuitive interfaces for designers/users with limited technical/programming background, to enable users to use advanced machines—such as KUKA industrial robot arms, with less programming.

2. Proposing a cost-effective in-house solution for human-robot interaction in the field of design and with a focus on accessibility and usability.

3. Developing a hardware-bridge between the KUKA robotic operation system and easy-to-use creative/interactive programming/software platforms.

In light of the mentioned themes, PX-Alpha Operator was developed and tested at the [Hidden-for-peer-review] (Figure 1, 2, and 3) . Architecture students—with limited or no programming background, have been asked to develop and control a robotic motion/task using PX-Alpha Operator and their software interface of choice.

Throughout the testing process and as a method to evaluate the success of PX-Alpha Operator, participants with no programming and coding background have been selected to use PX-Alpha Operator in conjunction with a simple Grasshopper 3D code, as a way to design and execute their first robotic motion design for robotic videography of an architectural physical model or modify an a robotic projection-mapping installation. Through these



PX-Alpha Robot Operator
PERSPECTIVE

Figure 1. Section-perspective of PX-Alpha Operator--Iteration PX02, showing the custom-made servo motors and the 3D-printed shell (Image by the Author).

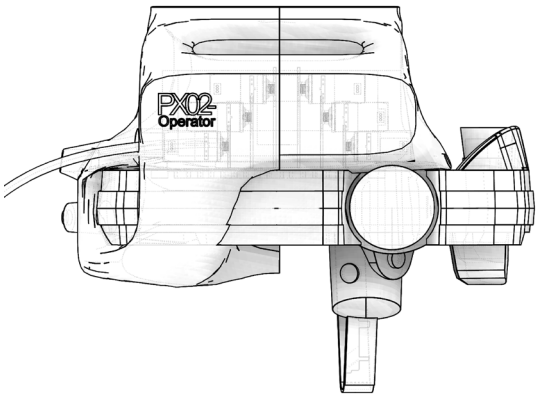


Figure 2. PX-Alpha Operator--Iteration PX02, connection to the KRC4 controller, Elevation view (Image by the Author).

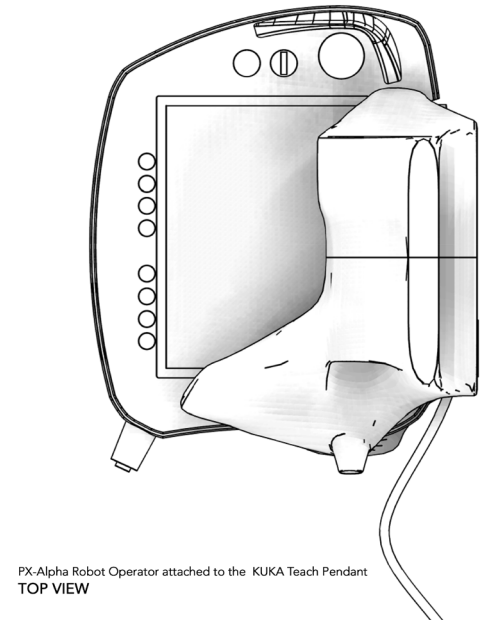


Figure 3. PX-Alpha Operator--Iteration PX02, connection to the KRC4 controller, Top view(Image by the Author).

back-and-forth design and test iterations, PX-Alpha Operator was developed as a prototype for a series of small installations (Figure 4 and 5).

For instance, as part of a robotic projection mapping installation, PX-Alpha Operator was used in combination with Kinect sensor and a MIDI controller—software usually used for music editing. As part of the installation, users visiting [Hidden-for-peer-review] lab could change the projection mapping and control the motion of the robot in realtime by simple MIDI inputs (Figure 6 and 7).

Another application example is the use of PX-Alpha Operator, to safely execute a predesigned robot motion, with realtime control over “stop”, “play” and “Pause” commands. Used as part of a robotic videography project, using PX-Alpha, users were able to control a predesigned robotic camera motion in realtime, through their interface of choice; In this iteration, students at [Hidden-for-peer-review] lab used a custom-made physical controller to control the camera motion based on the realtime footage of the camera.

RESULTS

Tested as part of an ongoing installation series, PX-Alpha Operator demonstrated the capability of adopting different input systems.

Ranging from custom-made multi-material fabrication processes, to interactive gesture-based installation, to safety-oriented stop/play operations, until now PX-Alpha Operator successfully employed various common inputs in the field of architecture, including but not limited to Kinect—depth-sensing camera, Arduino analog sensors, image-based inputs, and voice recognition triggers.

These applications along with the comparison between the users with or without technical background, demonstrated that PX-Alpha Operator can make it possible for users with limited programming skills to create realtime robotic interactions easier. Within few hours each of the users were able to control lab’s KR6 R900 Sixx robot from their preferred software/interface.

DISCUSSION

PX-Alpha Operator as part of a bigger body of design-research on HMI, is in its early stages of development. This research project seeks possible new methods to amplify the rising critical voice regarding the idea of democratization of design/fabrication tools and increasing their accessibility. Through suggesting an alternative for technical workflow of some of the cutting-edge tools—mainly adopted from other industries/disciplines, PX-Alpha Operator—and its sister research projects, aim to challenge the technical hierarchy/gap in the creative disciplines. By creating an “in-between” software/hardware, this project aims to make it easier for users to move beyond the technical limitations of a tool—robots in this case.

Figure 4. PX-Alpha Operator--Iteration PX02, 3D-printed prototype connected to KUKA KRC4 teach pendant controller (Image by the Author).

Figure 5.PX-Alpha Operator--Iteration PX02, 3D-printed prototype connected to KUKA KRC4 teach pendant controller (Image by the Author).

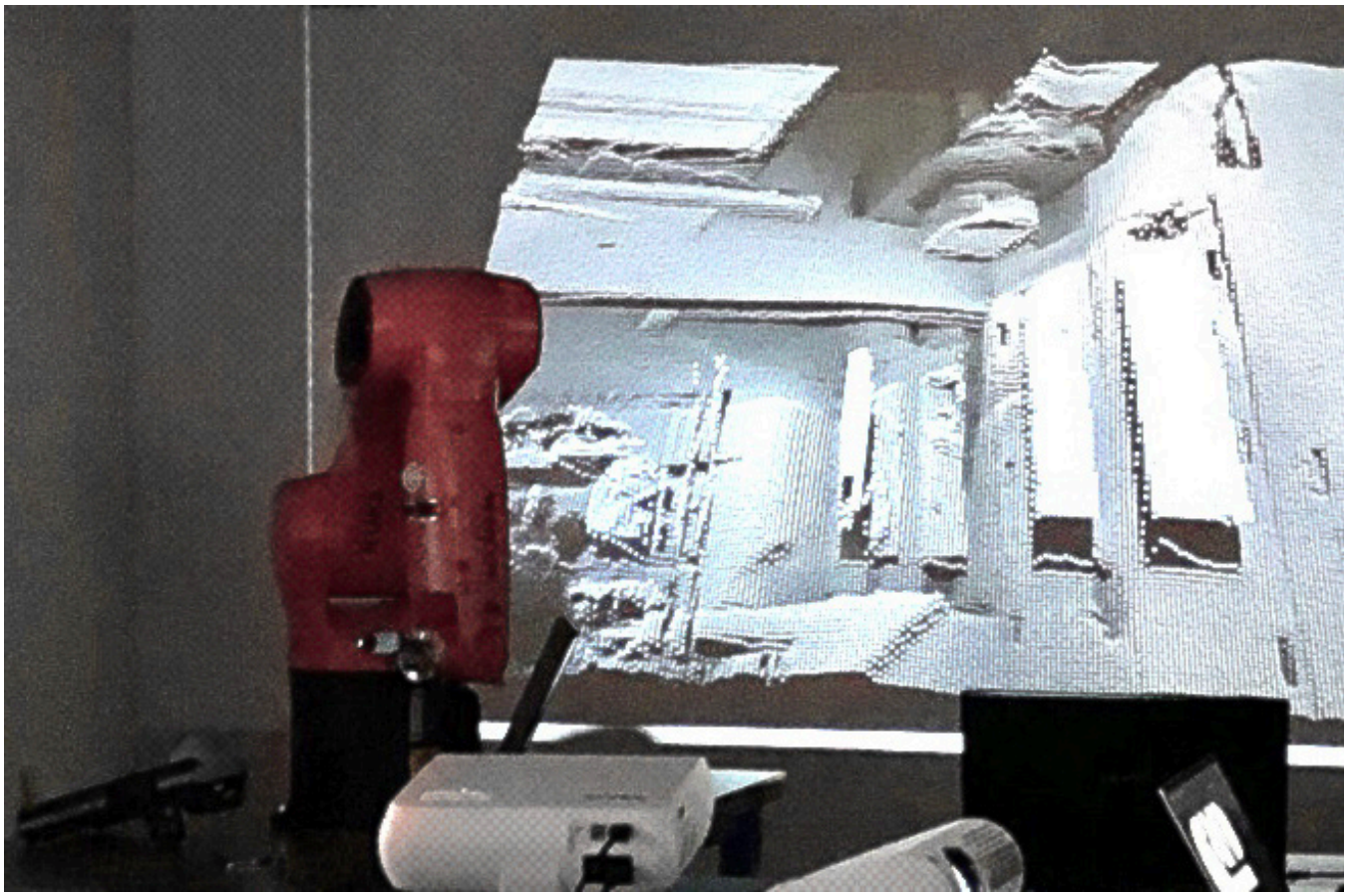


Figure 6.Controlling the projection mapping and robotic motion using PX-Alpha Operator--Iteration PX02 (Image by the Author).

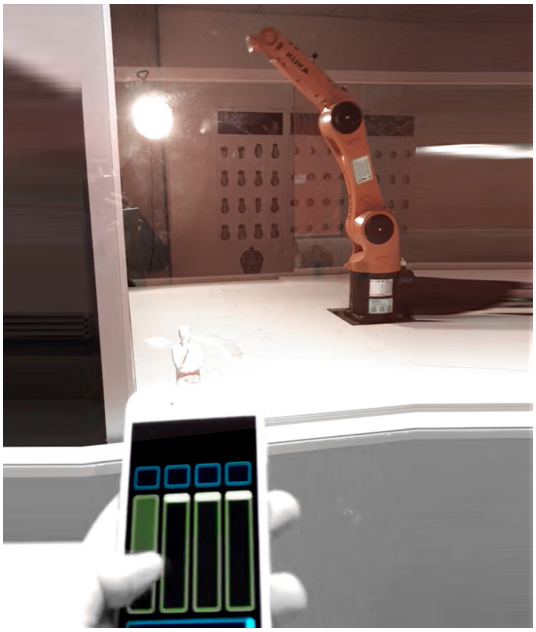


Figure 7.Controlling the robotic motion using cellphone-based MIDI controller in combination with PX-Alpha Operator--Iteration PX02 (Image by the Author).

ENDNOTES

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