Hand-based Tracking Animatronics Interaction

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***Abstract*—Natural user interfaces are becoming more affordable and are changing how people interact with daily activities. These interfaces take advantage of human ergonomics increasing comfort, accuracy and performance during several tasks. New trends in user interfaces allow developing innovative forms of interaction in different scenarios; such is the case of robot teleoperation where joysticks, voice command, inertial sensors, haptics, and even Kinect sensors are easing their usage in educational contexts where people is getting familiar with robotics. This project presents the development of hand tracking application whose motion controls different servos on an animatronic; the goal is to motivate better understanding of robot morphology, sensors, actuators and kinematics for beginners. The system was tested using the hand and fingers as the controller while basic concepts were presented. After using the application and the animatronic device, users found the idea compelling and expressed their motivation for more knowledge regarding robotics.**

***Index Terms*—Animatronics, Interaction, Motion, Tracking**

I. Introduction

User Interfaces (UI) are rapidly changing how users interact with several devices [1], current trends are focused on motion and gesture tracking ranging from hand [2], body [3], and facial traits [4], with several form of feedback through visual, haptics, and sound cues, that don't lose the research on human computer interaction due to minimalist interfaces such as touch screens [1]. These new UIs based on motion tracking are being used in several contexts, CAD [5], training [6], navigating [7], and entertainment [8], among many others.

Within an educational context, approaches for easing robotics learning have yielded to the development of several robotics kits [9][10][11], offering modular assemblies and visual programming based on blocks as the MIT app inventor [12]. Traditional input devices for programming and interacting with didactic robots are based on keyboards, keypads [13], voice commands, image processing [14], and more recently motion tracking [14], however, users mainly rely on hand interactions to perform tasks as its Degrees of Freedom (DOF) allow performing various grasps and movements through its dexterity. Didactic robot kits involve the assembly of kits requiring motor skills and spatial orientation, along with input devices for programming it. Most common input devices are keyboards, however, 3D user interfaces (3DUI) have also proven effective as complimentary means, due to their features, such as, spatial tracking through an object's six DOF, complimentary buttons, gestures and programmable functions. From an interactive point of view, 3DUIs present a more engaging scenario for newcomers to get introduced in robotics.

This project focuses on integrating an affordable 3DUI as an alternative input controller for better understanding the robot's morphology and kinematics basic concepts through hand motions, as means for increasing robotics interest in students of engineering not related with the area.

The document is organized as follows: In Section I the system architecture and a sensor analysis is presented; In Section II the methods are presented; in Section III the results are presented; and finally, in Section IV the conclusions are discussed.

II. Methods

The development of an animatronics robot involves several stages where the student design (sketch, CAD), built (3D printing, assembly) and control the mechanism (serial communication between motors and 3DUI), while learning basic concepts related to robotics provided with guides. The process begins with choosing an object to build, and then a sketch of the mechanism is created for identifying DOF, mechanism ranges of motion, possible actuator and sensor placement. Fig 1 presents an example of the design process, in this stage students familiarize with robot morphology, sensors, actuators and materials. Once the animatronics morphology is identified, the mechanism and the materials are chosen so the CAD representation provides the blueprints for prototyping the mechanism.

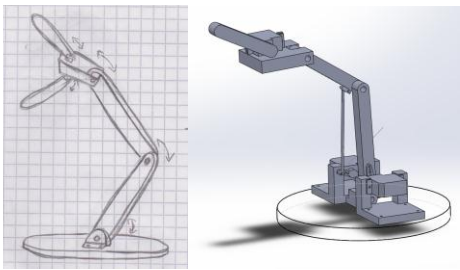

Fig. 1. Example sketch, CAD and animatronic projection

Having identified the materials and mechanism characteristics, the system architecture is organized allowing the student to identify which are the inputs and outputs for controlling the animatronic system. Fig 2 presents the system architecture, it can be seen that the user provide inputs through the 3DUI (translations and rotations) for controlling the animatronics whose execution feedback the user for correcting or creating new cues of motion. As the animatronics are modular, depending on the student several configurations can be achieved, resulting in an additional input for the animatronics block.

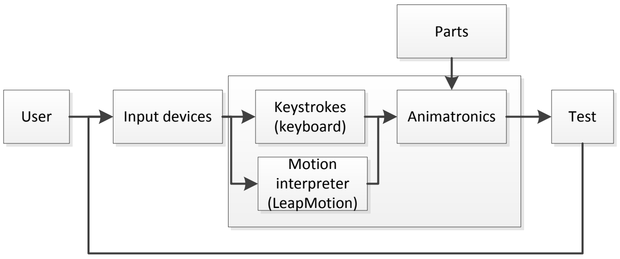

Fig. 2. System architecture

A. *Input devices and Communications*

Several devices are available on the market as suitable user interfaces for controlling the device, however, affordable 3DUIs are limited to the Kinect sensor that has been widely spread thanks to Microsoft's videogame consoles [15]. Current developments in 3DUI involve devices such as the Leap-Motion that uses three infrared sensors for tracking hand and finger movement [16], the MYO that reads miograhic signal for command mapping [17], research such as Microsoft's Sound-waves for gesture recognition using the computer's microphone with the Doppler effect [18] and Washington's University WiSee for gesture recognition by using unused wireless waves emitted from a router [19]. From these devices the Leap-Motion is currently the most affordable and computer manufacturer are supporting the device for its inclusion with several laptops [20], prompting an opportunity for taking advantage of this sensor and its features.

The Leap-Motion allows tracking the fingers of both hands through three infrared sensors that captures motion within while the hands are completely horizontal in respect to the sensor and their pronation/supination doesn't reach 90º. The sensor identifies each finger flexion/extension and adduction/abduction over all its phalanxes, allowing several combinations based on finger and gestures.

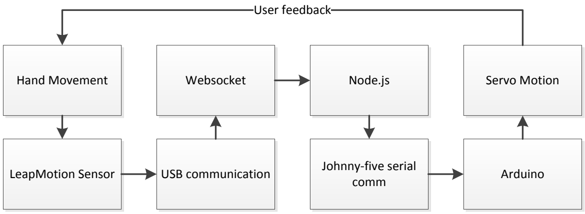

Fig. 2. Leap-Motion communications

Additionally, in case the user experience interaction issues due to lighting conditions that may affect the sensor performance, keyboard inputs are also available for controlling the mechanism servos.

B. *Mechanism and actuators*

The mechanism design and assembly consists of aluminum profiles or PLA 3D printed pieces for avoiding heavy structures that DC servos cannot move. During the CAD design process students configure materials and can determine in advance what modification must take place for moving the animatronics with selected servos.

The system is configured for detecting flexion/extension and abduction/adduction rotations for rotating the DC motor axis accordingly to the animatronics mechanism, as presented in Fig 4.

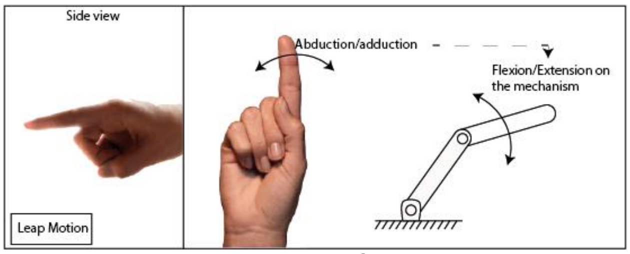

Fig. 4. System architecture

III. Results

Through this project various animatronic mechanisms were designed and developed by a group of students following the design processes, CAD validation and assembly, some of these works are presented in Fig 5.

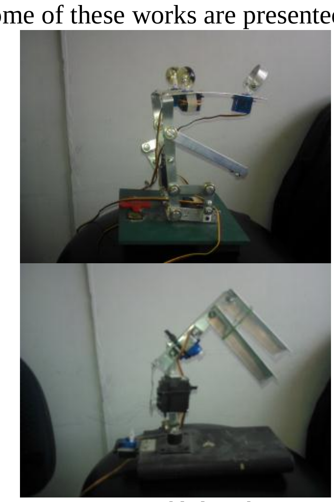

Fig. 5. Assembled mechanisms

Once the mechanisms were assembled, the system was set up for controlling it with the Leap-Motion, whose motion data was sent for controlling each motor. The tracked data allowed controlling the servos for performing each of the mechanism's rotations, as presented in Fig. 6 where the abduction/adduction motion allows opening/closing an animatronic's jaw.

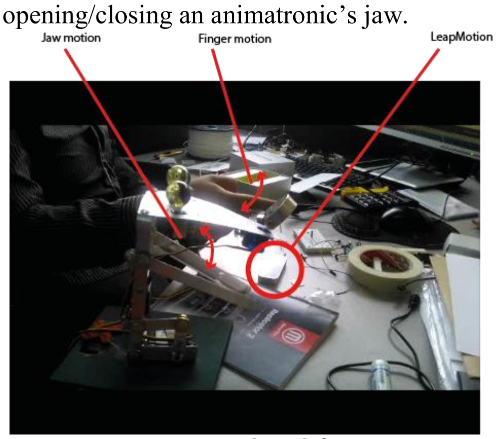

Fig. 5. Jaw movement through finger motion

After completing the task, the students were asked to detail the experience and a survey was applied for analyzing if the UI made a difference in their motivations for getting familiar with basic concepts of robotics. Two groups of students were surveyed, the first only controlled the devices through keyboard, and the second used the Leap-Motion. Users that used the keyboard manifested interest in trying other UIs such as the wiimote, Kinect or gamepads, while those using the Leap-Motion manifested being more drawn to program and control the device rather than using the keyboard. A common factor in both groups that created fear among students was the fact that thinking of basic robotics as a complex topic only boarded by specialists.

IV. Conclusions

Interaction plays an important role when encouraging students to get the basics of robotics, the activity of designing, modeling, assembling and controlling an animatronic motivate the users to engage in basic robotics concept leaving aside the fears of complexity or difficulty associated with the topic. Motivation was also affected, as the students found more interest in programming and controlling the mechanisms with 3DUIs rather than traditional UIs.

Future works will focus on expanding the experience to younger groups in high schools and tele-operating robots via web for understanding basic tele-operation concepts.

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References

[1] F. Weichert, D. Bachmann, B. Rudak and D. Fisseler, "Analysis of the Accuracy and Robustness of the Leap Motion Controller," *Sensors,* vol. 13, no. 5, pp. 6380-6393, 2013.

[2] Thalmic, *MYO,* 2013.

[3] I. Tashev, "Kinect Development Kit: A Toolkit for Gesture- and Speech-Based Human-Machine Interaction [Best of the Web]," *Signal Processing Magazine, IEEE,* vol. 30, no. 5, pp. 129-131, 2013.

[4] W. Steptoe and L. Zhao, "Poster: Using the whole body for multi-channel gestural interface," in *3D User Interfaces (3DUI), 2013 IEEE Symposium on*, 2013.

[5] B. Spanlang, X. Navarro, J.-M. Normand, S. Kishore, R. Pizarro and M. Slater, "Real time whole body motion mapping for avatars and robots," in *Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technology*, 2013.

[6] J. Smisek, M. Jancosek and T. Pajdla, "3D with Kinect," in *Consumer Depth Cameras for Computer Vision*, Springer, 2013, pp. 3-25.

[7] B. Roitberg, P. Banerjee, C. Luciano, M. Matulyauskas, S. Rizzi, P. Kania and J. Gasco, "Sensory and motor skill testing in neurosurgery applicants: a pilot study using a virtual reality haptic neurosurgical simulator.," *Neurosurgery,* vol. 73, pp. S116--21, 2013.

[8] Q. Pu, S. Gupta, S. Gollakota and S. Patel, "Whole-home gesture recognition using wireless signals," in *Proceedings of the 19th annual international conference on Mobile computing \& networking*, 2013.

[9] N. F. Polys, F. Bacim, M. Setareh and B. Jones, "Building novel Web3D user interfaces: a case study from architecture and structural engineering," in *Proceedings of the 18th International Conference on 3D Web Technology*, 2013.

[10] MIT, *MIT APP invetor,* 2013.

[11] R. Kreifeldt, H. Roth, O. Preissner and T. V{\"o}hringer-Kuhnt, "Interfaces using gestures—Today's technology, tomorrow's innovations," *Auto Tech Review,* vol. 2, no. 3, pp. 50-54, 2013.

[12] L. M. Inc., *World's First Computer Embedded with Leap Motion Technology to Hit Shelves This Fall.*

[13] R. Hitec, *Robonova,* 2013.

[14] K. Hald, "Low-cost 3DUI using hand tracking and controllers," in *3D User Interfaces (3DUI), 2013 IEEE Symposium on*, 2013.

[15] C. Guo and E. Sharlin, "Exploring the use of tangible user interfaces for human-robot interaction: a comparative study," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2008.

[16] Festo, *Robotino,* 2013.

[17] M. Camara, P. F. de Abreu Braz, I. Monteiro, A. Raposo and S. D. J. Barbosa, "Evaluating devices and navigation tools in 3D environments," in *Human-Computer Interaction. Interaction Modalities and Techniques*, Springer, 2013, pp. 439-448.

[18] G. Bruder, F. Steinicke and W. Sturzlinger, "To touch or not to touch?: comparing 2D touch and 3D mid-air interaction on stereoscopic tabletop surfaces," in *Proceedings of the 1st symposium on Spatial user interaction*, 2013.

[19] P. Baudisch, "Natural user interface hardware," in *3D User Interfaces (3DUI), 2013 IEEE Symposium on*, 2013.

[20] Y. Bar-Cohen, "Humanlike Robots: Synthetically Mimicking Humans," in *Mechanics of Biological Systems and Materials, Volume 5*, Springer, 2013, pp. 57-61.

[21] D. Alimisis, "Educational robotics: Open questions and new challenges," *Themes in Science and Technology Education,* vol. 6, no. 1, pp. pp--63, 2013.