Proposal JECA, Psychophysical Rehabilitation game using Kinect and Robotino.

Carlos G. Pillajo,
cpillajo@ups.edu.ec
Javier E. Sierra
Javier.sierra@upb.edu.co

Abstract - This paper presents an alternative iteration of a mobile robotic system (Festo Robotinos) for tracking an optimal route by proposing an iterative game that will serve the psychophysical rehabilitation by the user will interact with the Robotinos by a sensor Microsoft Kinect. The system consists of the Kinect sensor, Robotinos , a flat base where the roads are drawn by which the robot can go, the operation is common sense so that the user to move their upper limbs generate data provided by your skeleton moving this data will be interpreted through the Kinect sensor to control the movements of the robot. The game interface and all of its programming is in C # development language because both the Kinect sensor as Robotinos have libraries for this language. The proposed system will be used for physical rehabilitation therapies for people who have restrictions on their movements of the upper extremities

Indices - Game , Kinect , Robotino.Rehabilitation

I. Introduction

The application of robotics in modern times is a necessity in almost all areas of our daily lives, remembering that the first applications of robotics in the industrial field were such that optimized production currently developing robots are aimed to provide services , ie to help people in everyday tasks as well as sick care, assistance in professional activities , and so on. [1], the trend in the field of robotics is to solve everyday problems or provide alternative solutions increasing the capabilities of autonomous mobile robots in unknown environments by integrating human experience [2], [3] increasingly have greater autonomy and robots are used in: industry , services , hospitals, etc. [4] the autonomy of the robots is obtained by the intersection of research in various fields such as social science , artificial intelligence , robotics, computer science , communications [5] the medicine. Moreover, in order to respond to users with mobility limitations , the use of traditional interfaces such as keyboards , joysticks are in need of being replaced by more intelligent sensors, hands-free as Kinect, which is based on pattern recognition generated by your camera depth of the patterns of the upper extremities are used. [6]

In the tasks of autonomous mobile robots for the exact location is a fundamental prerequisite for successful navigation [7], scale environments for mobile robot handling a wide range of sensors is needed with good performance is reason used mobile system Robotinos Festo [5] [8] [9].

One JECA game which is a game using iterative sensor Kinect interpreting the skeleton movements allowing to know the distance of the relative movements of the both right and left hand , these data generates control commands for the movement of the robot is proposed to be placed on a base having established routes and obstacles that must be dodged by the user's movements thus achieving an iterative game motivating users to perform movements of his upper extremities generating psychophysical rehabilitation exercises. Is a brief description of the system hardware consists of the Kinect sensor in the next sections of this paper , mobile robot Robotinos Festo , the mathematical model of the mobile robot will be reviewed , the algorithm applied to optimize the path diagram of the algorithm positioning generated Kinect , experimental results , and finally some conclusions.

II. Architecture JECA

The JECA system proposed consists of a Micosoft Kinect sensor [10] [11] [12], a signal PC with wifi enabled, a Robotinos, a flat base where the possible paths are drawn movable Robotino. The data generated by the movement of the upper limbs of the user, are acquired by the camera depth of Kinect sensor that is connected through a USB PC serial port where the information is processed and control instructions are generated for robotino.The architecture of JECA system is based on the Kinect sensor which sends the data to the PC where the data acquired is processed , and the output data is generated for controlling a mobile robot either naturally or based on the algorithm optimal path Dijkstra [13] (Figure 1). Kinect is a motion detection sensor having a chamber, which interprets 3D media information from a continuous infrared structured light projection . It has many applications one of which is to track the human skeleton, and therefore recognize the human motion , the valid range of the sensor is about 0.4- 4m . [6]

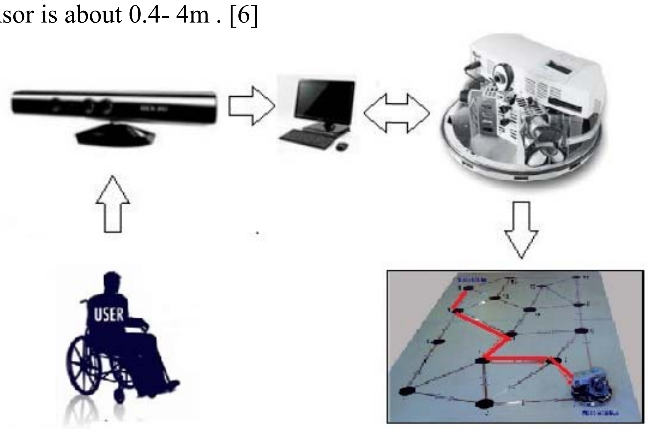

Figure. 1. Subclass of JECA system.

The proposed system consists of two JECA clearly defined parts consist of Hardware and Software

A. System Hardware JECA.

The proposed system is physically constituted by: Microsoft Kinect Sensor as a depth measurement to record the user's movements, Kinect is an alternative device capable of capturing a color image and depth, the same real time. The depth sensor consists of an infrared laser projector and a monochrome CMOS [14] sensor that captures video data in 3D under any ambient lighting condition. The resulting point cloud can be uploaded to a computer using open source libraries, Kinect uses to operate with Windows 7. The data connection to the computer is through a USB interface, use this sensor to record the points of the skeleton Kinect considering that returns an image of depths.

Robotino of Festo as mobile robotic system on which the user can view the act on their movements on a basis where trajectories are drawn to serve as guides. Robotino is a product of the division Didactic is a mobile system with omni-directional actuator, a learning system for training and development to be a powerful platform for research and development, Omnidirectional operation allows you to make movements forward, backward and sideways also allowing turn on a particular point , all this added to the incorporation of analog, digital sensors and a webcam for iterating through artificial vision. All this built into your CPU , which integrates an embedded system with computer features performance industrial PC- 104 and Linux operating system with real-time kernel . The distribution of the 3 engines , separated from each other by 120 ° , along with omnidirectional wheels allow movement to different locations in a coordinate system in two dimensions , are subject to a stainless steel base , delivering you a innovative design , for use in practical tasks . Operation through Robotinos VIEW software , allows highly didactic program , incorporating design and functional programming sequential blocks , all connected via a wireless LAN , which allows a permanent and continuous connection with the operation of the equipment, and its sensors. Its simulation software operation through Robotinos DEMO SIM , allows a highly didactic display [5] .

B. System Software JECA

The software used for the system was developed in C # language, as both the Kinect as Robotinos have libraries that dock and can schedule them in this language addition Dijkstra's algorithm for the purpose of executing the game, which is to guide developed mobile robot for the shortest path between two points.

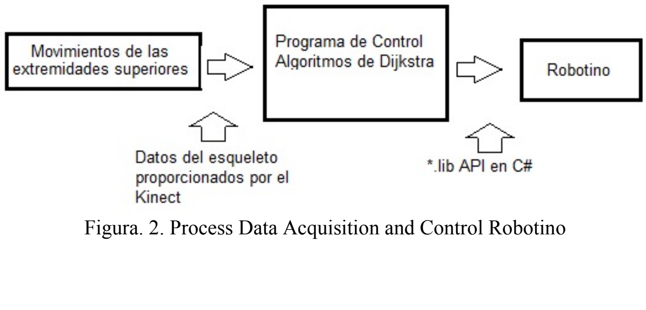

Figura. 2. Process Data Acquisition and Control Robotino

The acquisition of Data provided by the upper extremities of the skeleton of the human being described in Figure 2, where it can be seen that these movements will be interpreted by the camera depth of Kinect to control commands to be programmed algorithms by language C # for the operation of Robotinos be scheduled such that: if man raises his right arm the robot will move forward if the right arm down anger robot back, if the human moves his left arm to the left the robot goes to the left if the left arm to the right robot will move to the right, but these movements can be configured depending on the needs and physical exercise to move.

C. Kinematics of Robotino.

The kinematic structure of a mobile robot , can be considered as a set of closed kinematic chains , so as wheels in contact with the ground. Likewise, wheel - ground interaction is defined , from the kinematic point of view , as a planar joint with three degrees of freedom as shown in figure 3 , where one of them , usually uncontrolled represents the lateral slides . [15] Al assumed the wheel as a rigid element , it comes into contact with the floor at one point , which serves as the source system attached references drawn in Figure 3 . Vy direction determines the normal direction of advancement of the wheel Vx axis indicates the lateral slides , and Wz the rotational speed which occurs when the vehicle makes a turn . In the case of a conventional wheel , the Vx component is assumed always zero , however , there are wheels designed for removing said constraint . The omnidirectional wheel is defined as a standard wheel to which the crown provided with a roller , whose axes of rotation are perpendicular to the normal direction of travel. Thus, by applying a lateral force , the rollers rotate on itself and allows the non-null component Vx , and thus no restriction is removed holomicidad

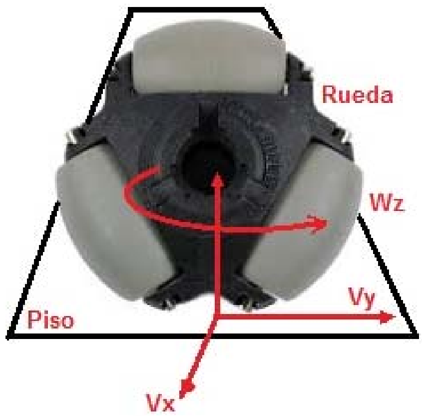

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Figure. 3. Robotino wheel contact with the floor

An important part of this work is to implement a mathematical model for the omnidirectional robot kinematics, the geometry of the kinematic study robototino object shown in Figure 4, the simulation is presented in [16].

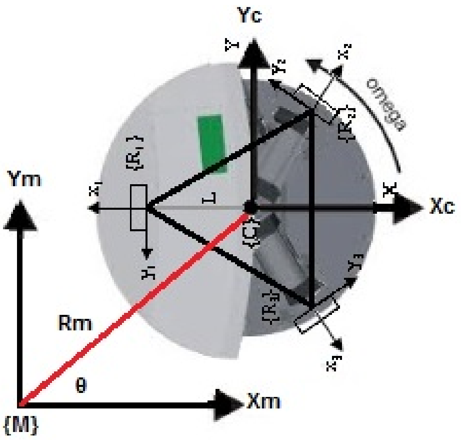

Figure. 4. Kinematic Robotino Outline

The kinematic configuration of the robot is defined by an equilateral triangular frame, in whose vertices are arranged three omnidirectional wheels. The distance from the origin of {C} system (located in the geometric center) of any of the wheels is given by L. All wheels are defined as non-addressable. Table 1 lists the values of the parameters of the kinematic model given in [15].

	Wheel 1	Wheel 2	Wheel 3
αi	180	60	-60
βi	0	0	0
γi	0	0	0
δi	(0,0,0)	(0,0,0)	(0,0,0)
λi	(-L,0,0)	(L/2,L√3/2,0)	(L/2,-L√3/2,0)

Table. 1. Kinematic configuration parameters.

In order to obtain the wheel jacobieano the matrix Ji (1) is multiplied by the conversion matrix for omnidirectional wheels acting presented in the following expression (2)

$$\begin{pmatrix} V_{Cx} \\ V_{Cy} \\ \omega_C \end{pmatrix} = \begin{pmatrix} C_i & -S_i & p_{iy} & -\lambda_{iy} \\ S_i & C_i & -p_{ix} & \lambda_{ix} \\ 0 & 0 & 1 & -1 \end{pmatrix} * \begin{pmatrix} V_{ix} \\ V_{iy} \\ \omega_i \\ \beta_i \end{pmatrix} \quad (1)$$

$$V_C = \hat{J}_i * \hat{q}_i$$

$$W_i * q_i = \begin{pmatrix} 0 & r & 0 \\ -R & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix} * \begin{pmatrix} \omega_{ix} \\ \omega_{ir} \\ \omega_{iz} \end{pmatrix} \quad (2)$$

The Wi matrix models, in this example, a wheel of radius R, rotating with radius r rolls ninety degrees, tractor and not addressable. Furthermore, with respect to the vector q ˙ Wix is the degree of actuation of the motor, wir the angular speed of the rollers and sliding wiz the vertical rotational axis of the wheel. Thus, the Jacobian of the ith wheel is reflected as follows:

$$J_i = \hat{J}_i * W_i = \begin{pmatrix} R * S_i & r * C_i & \lambda_i \\ -R * C_i & r * S_i & -\lambda_i \\ 0 & 0 & 1 \end{pmatrix} \quad (3)$$

The parameters of Table 1 in the expression (3) are replaced, and the Jacobian for each of the wheels are obtained. This Jacobian matrix relating the vehicle speed with the rotation wheel shown in: acted, sliding along the vertical axis, and rollers. From the point of view controlling interest exclusively actuated degrees.

Equation (4) as is the Jacobian matrix act on study mobile robot.

$$\begin{pmatrix} V_{Cx} \\ V_{Cy} \\ \omega_C \end{pmatrix} = \overbrace{\begin{pmatrix} 0 & \frac{R}{\sqrt{3}} & \frac{-R}{\sqrt{3}} \\ \frac{2R}{3} & \frac{-R}{3} & \frac{-R}{3} \\ \frac{-R}{3L} & \frac{-R}{3L} & \frac{-R}{3L} \end{pmatrix}} * \begin{pmatrix} \omega_{1x} \\ \omega_{2x} \\ \omega_{3x} \end{pmatrix} \quad (4)$$

Robot odometry means the use of the motion data of the three actuators to estimate the position of the robot with the time. In the current design problem we use odometry to estimate the relative position of the mobile robot from its location. Thus, using the kinematic model of the robot and by integrating speed robot mobile robot position is found. Some considerations are made: a) The friction between the wheels and the ground is infinite b) The center of mass is located in the geometric center of the robot; c) The distance between the center of the robot and the center of the wheel is constant [5].

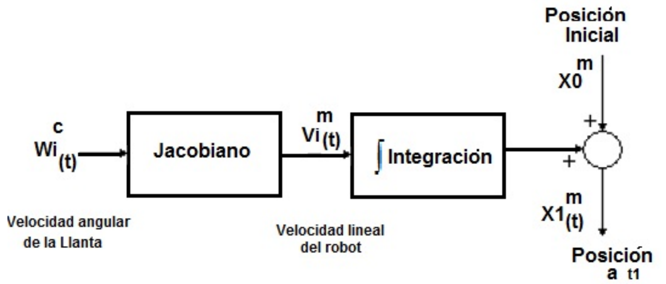

Figure. 5. Kinematic model of Robotino

III. ALGORITHM OF INTERFACE JECA

A. *Concept of Open NI libraries for Control*

In order to make full use of the Kinect sensor, OpenNI (Open Natural Interaction) software was used. OpenNI is a multi - language , multi - platform framework that defines APIs for writing applications utilizing natural interaction . OpenNI API consists of a set of interfaces for writing NI applications [6] . In OpenNI , the human skeleton is composed of joints, each joint of a set of information that contains the location and orientation is obtained. Therefore, some functions are defined for skeletal information such as: Skeleton SkeletonCapability The capacity also allows a user to generate the output data of the skeleton of the user, that is, where each joint is located .

SkeletonJointOrientation A joint orientation is described by its actual rotation and the confidence we have in that rotation The first column is the X direction , where the value increases from left to right. The second column is the Y orientation , where the value increases from bottom to top. The third column is the orientation of Z , where the value increases with distance .
SkeletonJointPosition The position of a joint is described by its actual position and the confidence we have in that position. All joints of the skeleton can be provided by OpenNI directly define the location of the hinges (except for the fingers) , and i . the skeleton of the user . Therefore, no statistical classifier is required. One can calculate the angle of each joint in real time , and then the pattern of movement that defines the relative angles between the joints.

The API is an interface for communication between the software and components Robotinos , allowing full access to the sensors and actuators. There is an API for Windows and one for GNU / Linux , each API has several libraries that developers can use to develop applications in different programming languages such as . Net, C + + , C , C # and Java , making control Robotinos more customized.

B. *Flowchart of the algorithm implemented*

The program has a main screen where you select two options: a) if you want to follow the path between two points manually and b) if you want to find the optimal path and follow it. If the first option is selected a screen where the user will follow marked trails at the base between the points he wants to freely be presented. When the second option is selected is entered on another screen where the user selects two start and end points are the points between which you want to find the optimal path. Since it has been selected start-end points (AB) must be placed in the starting point (A) to implement Dijkstra's algorithm [13], the Computer process and submit the shortest route between these points, the challenge of Users carry the mobile robot is the ending point (B) on the traveled path in the shortest time possible.

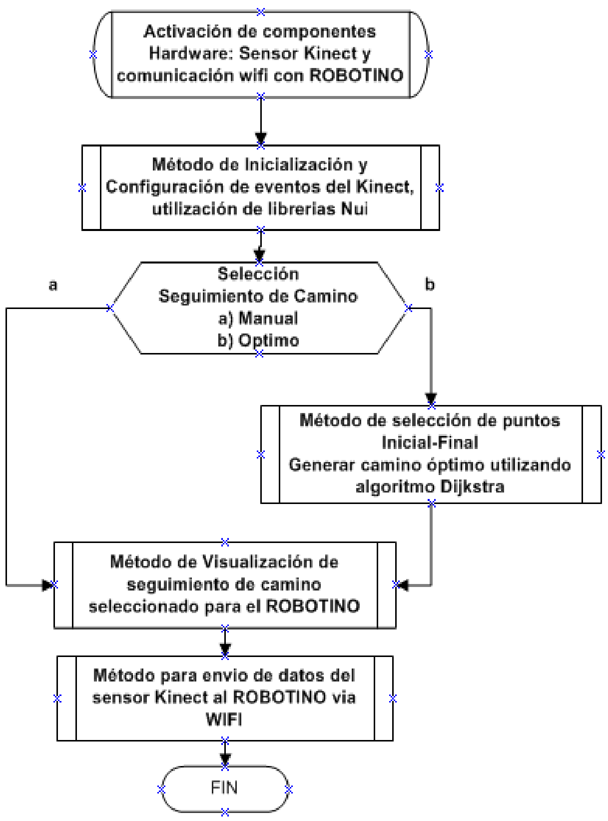

Figura.6. Diagrama de flujo del algoritmo para control del ROBOTINO

The program begins with the activation of the hardware components used in the application such as the Kinect sensor and wireless communication enable Robotinos, then runs the Initialization method which enables Nui bookstores continues with the selection of the way forward the user option if you only want to follow a path freely and b option if the user wants to follow the optimal path between two points previously selected this option Dijkstra's algorithm is executed, regardless of the option selected then the method is executed display the way forward for the mobile robot, the last method of control data sent to the Robotinos runs wirelessly. (Figure 6)

IV. Results and Discussion

A. *Results.*

After making and implementing the algorithm described above settings are made as to the acquisition of data from Kinect sensor, then the sending sensor data is highly variable, so that ranges of values and time delays are established to be conducted control actions for Robotinos motion.

Traditionally, rehabilitation of older people with mobility problems is performed by physical therapists often perform exercises in which patients should do different movements with his arms in almost unmotivated relaxed environments, introduces a simple game where the goal is to achieve and keep the user's attention to the robot while physically moves while the user interacts in a specific range with the mobile robot. Based on qualitative research we noticed the acceptance of the game for seniors.

B. *Discussion*

Observations on the use and basic prototype show that older people are well aware that the robot is an inanimate object, and still limited to the robot behave as if it had the same personality and emotions. How it influences the effect of the practice of robots based games is not well researched, but this work indicates that the game with the robot is relatively simple and that the proposed game lacks complex challenges. Intrinsically users associate robot with features that are not as well as capacity to see, hear and even feel.
It has been observed that the robot encourages social interaction for older users, this can be seen as a positive cognitive training needed by the elderly because they have functional declines and fall into passivity

V. CONCLUSIONS

To our knowledge , the use of a mobile robot on the basis of a physical game that motivates for physical action has not yet been investigated . We present a set of robot as a way to motivate the elderly and people with limited that they can perform physical exercises for rehabilitation capabilities.

The study showed that older people had no problem in understanding that is inanimate robot with limited capabilities , yet during the game tended to treat it as a living being with broader capabilities.

When the game was shown that due to the nature of the game in the elderly made a series of physical movements that would be difficult or even painful in normal conditions this can be used for training the system control posture, balance and orientation human.

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