INFOTEH-JAHORINA Vol. 11, March 2012.

Robotics in Art

Robot Flower

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Abstract— **This paper presents two solutions for a robotic device. One of them has already been made and presented at a prestigious art exhibition in Berlin, while the other is designed in two versions and variants of its forthcoming production. The first represents the robotic tree, the *Dancing Tree*, with one degree of freedom of movement, while the other, the *Robot Flower*, has two degrees of freedom of movement around two axes of rotation, and a synchronised performance is the result of selection of different axes of rotation.**

***Keywords*; robot flower; dancing tree;**

I. Introduction

In the recent past, we studied, explored and constructed robots primarily for industrial purposes, sometimes humanoid and sometimes medical, but we seldom or never met with robots in the arts. Robots or rather robotic devices in the arts, are intended to interact or engage our attention in a different way from the classical works of art, such as paintings, sculptures or photographs.

According to the definition: Robotic art is a broad term that encompasses a variety of sub-types of art, all of which employ some form of robotic or automated technology. Robotic installation art unifies installation art and robotic technologies insofar as the works and installations often employ computers, sensors, actuators and programming which allow them to respond or evolve in relation to viewer interactions. In this kind of art and technology-based work the viewer is transformed from a passive viewer to an active participant. One significant way in which this work can differ from kinetic art is that it is usually non-programmatic in the sense that the future behavior of the sculpture or installation can be altered by input from either the artist or the participant.[1,2]

The history of robotics in the arts goes back to ancient China, where we can find the very beginnings of robotic devices that mimic the mechanical sense of the real world. Early progenitors start in Han Dynasty, c. third century B.C., with the development of a mechanical orchestra, and other devices such as mechanical toys. These last included flying automatons, mechanized doves and fish, angels, dragons and automated cupbearers, all hydraulically actuated for the amusement of Emperors by anonymous engineer-craftspeople. In Ancient Rome in the time of Nero, the great poet and novelist Petronius made a ‘doll that moved’.

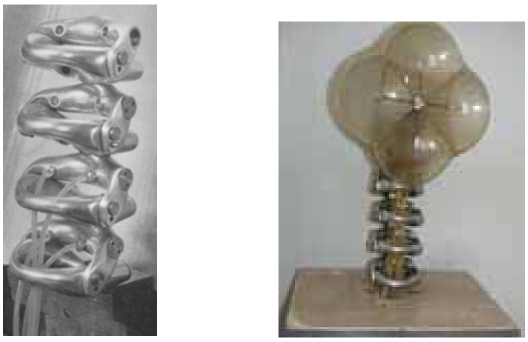
These mechanisms were all made with the primary aim of drawing attention and provoking a reaction from adaptable observers or listeners. Even the famous Leonardo da Vinci invented several theatrical automata including a lion that walked onstage and delivered flowers from its breast, and a soldier. After Karel Capek first used the word ‘robot’ and Isaac Asimov first used the word ‘robotics’, many predicted the current achievements in the field of robotics. [3,4,5]

Contemporary use of robotics in the arts covers different fields: for example, German artist group ‘robot lab’ works with industrial KUKA robots in public spaces. It explores the relationship between man and machine by means of installations and performances. ‘Juke bots’ is an installation, in which two robot arms are creating sound by means of records.

A. Robot Sculpture

The first moving sculpture, which moved directly and recognizably in response to what was going on around it, was SAM (Sound Activated Mobile). It was exhibited at the 'Cybernetic Serendipity' exhibition, which was held initially at the Institute of Contemporary Art in London in 1968 and later toured Canada and the US ending at the Exploratorium in San Francisco. SAM consisted of an assembly of aluminum castings somewhat reminiscent of vertebrae, surmounted by a flower-like fiberglass reflector with an array of four small microphones mounted immediately in front of it. The vertebrae contained miniature hydraulic pistons, which enabled them to move in relation to each other so that the whole column could twist from side to side and lean forwards and backwards. A simple electronic circuit used the signals from the four microphones to determine the direction, which any sound in the vicinity was coming from and two electro-hydraulic servo-valves moved the column in the direction of the sound until the microphones faced it.

The resultant behavior, that of following the movement of people as they walked around its plinth, fascinated many observers. Also, since the sculpture was sensitive to quiet but sustained noise, rather than shrieks, a great many people spent hours in front of SAM trying to produce the right level of sound to attract its attention. SAM is still in existence. It is not currently working as some of its components were removed (mostly the hydraulic hardware).



a) *b)*

Figure 1. a) SAM as it appeared in the catalogue for the Cybernetic Serendipity Exhibition at the ICA, b) SAM as it looks now (2004).

SAM was created by a robotic artist Edward Ihnatowicz, who later also created The Senster (1969–71). Commissioned by Philips, it employed sound sensors and hydraulics, which reacted to visitors in the 'Evolution', in Eindhoven, the Netherlands, where it was on display from 1970 to 1974, when it was dismantled. It was the first work of robotic sculpture to be controlled by a digital computer. It was about 2.5m high 'at the shoulder' and about 15.4 m long, constructed of welded steel tubing and actuated by hydraulic rams. There were four microphones and two Doppler radar sensors mounted on its 'head', which were used to sense the sound and movement of the people around it.[6,7]

A computer system (Philips P9201 - a clone of the more common Honeywell 416) controlled the robot and implemented a behavioral system so that the Senster was attracted to sound and low-level movement, but repelled by loud sounds and violent movements. The complicated acoustics of the hall and the completely unpredictable behavior of the public made the Senster's movements seem a lot more sophisticated than the software would suggest. Its size - it was over 15 feet (4 m) long and could reach as high into the air - made the use of aluminum castings inappropriate, so it was welded out of steel tubing, with the castings employed only in the more intricate microphone positioning mechanism. Its behavior, controlled by a computer, was much more subtle than SAM's but still fairly simple. The microphones would locate the direction of any predominant sound and home in on it, rather like SAM but much more efficiently, and the rest of the structure would follow them in stages if the sound persisted.[8,9]

a) *b)*

Figure 2. a) Senster, From Philips Archive, 1971, b) Senster in 2003

II. BASIC ASSUMPTIONS

The intention of this structure is to attract attention of observers and engage them in active interaction via the device's sensors. The final goal is for sculptures to be supplied with various sensors so that external disturbance or change generates appropriate activity from the driving system i.e., the performance of the programmed movement. In particular, changes in light intensity, temperature or sound in the environment should produce a reaction of the sculpture, which will then respond with appropriate movement.[10]

Figure 3. Motor gear housing

The *Dancing Tree* is the sculpture with a rotation around the vertical axis. With the one rotation, it achieves the effect of raising the branches. The layout is shown in Fig. 3. The drive system consists of a Globe DC motor and planetary gearbox with gear ratio = 81.37, and provides enough torque and appropriate speed for this slim structure. Motor-reducer is built into the hard aluminum case that is drilled along the surface to locate sensors that react to change in light intensity. When the observer interrupts the light source, the geared motor is activated and goes into vertical rotation for a few seconds. This is made possible by choosing the right sensor-type to activate the driving system. The sculpture also incorporates PVC leather 'foliage' around the central bearing aluminum tube, (1 m long), which is planted on the gear output shaft. Fig. 4. and 5. show images the *Dancing Tree* at rest and during motion. The sculpture was presented in January 2012, with the viewers successfully engaging with the sculpture, at the solo exhibition at the well-established Gmür Projects Gallery in Prenzlauerberg, Berlin. The next phase of this project is to create the robotic flower with two rotations, i.e. with 2 DOF. The flower, whose petals will be made by

Figure 4. The Dancing Tree in idle

Figure 5. The Dancing Tree in the move

using CNC casting technique, will have the diameter of 600 mm and the weight of about 15 kg. According to these requirements two types of platforms have been designed with two degrees of freedom of movement, i.e. two mutually coupled segments for vertical axis movement of rotation, and perperndicular axis, which enable the complex movements of the flower. Two DC motors with planetary gearboxes Globe type 102A200 with gear ratio 306:1 are used, as high torque is required for starting the movement of the solid cast, and there is the need for light flower rotation. Position in space will be determined by the built-in potentiometers that are also connected to the output shaft of the drive gear motor by small timing belts. All hardware along with electronics and power supply, which consists of two 12 V batteries, is located in the aesthetic casing below the ‘flower head’. In the following figures (Fig. 6. and 7.) the appearance of both versions of the active flower sculpture is given.

Figure 6. Flower (first variant versions)

Figure 7. Flower (second variant versions)

The further development includes the goal of producing multiple flowers that will be set together and presented as a floral field. Connected to and controlled by the PC, they can be synchronized to move and can also perform various individual movements. (Fig. 8.)

Figure 8. Floral field

III. CONTROLLER DESCRIPTION

Controller for the system is developed under the TMS 320 DSP controller. This is chosen because this type of controller is capable of directly driving the motor and collecting all the various signals from the sensors. Control block has several separate blocks:

1- Power control unit.
2- Motor control block.
3- Sensor unit.

Power unit is realized to provide power supply from the 12V battery. It provides power to the motor control unit, sensors and controller. Several voltages are needed 5V, 12V, and 3V are all regulated.

Motor control block are realized via HMOS bridge. It is directly controlled trough to DSP TMS320 PWM. Over current, under voltage and over voltage protection, as well as short circuit protection, is included.

Sensor unit is designed to detect events in the environment. Controller board is equipped to detect several types of events:

- Rapid change of the temperature could be detected. Using IR sensor type IRE5 photo transistor, it is possible to detect rapid temperature change caused by body temperature. In this way it is possible to detect a person who passes near the sensor. Using multiple sensor network it is possible to detect person approaching to the sculpture.

- The photo detector registers change in lighting conditions near the sculpture. Photo detector is capable of detecting small changes in the instensity of the daylight near the sculpture and subsequently the DSP controller will react according to the intensity and duration of the disturbance of change.

A. How the movement occurs

TMS 320 DSP is programmed to detect events that can move the sculpture. An event is the temperature change or intensity of light change. If temperature change occurs, controller has to detect if the change is rapid or slow. If rapid change occurs, than this is probably a visitor approaching the sculpture. Subsequently, the controller must memorize a new value of temperature to detect when visitor leaves the environment. Also, the controller starts the movement of the sculpture. Movement of the sculpture lasts for about 20 seconds, after which the sculpture stops moving for the next 10 seconds and any event that occurs in that time should be ignored. A new event will cause a new movement of the sculpture only after the 10 seconds have expired. The DSP controller also monitors all the temperature sensors (sensor network) and maps the temperature structure in the field of the sculpture. This allows the controller to monitor not only a single visitor, but also groups.

A special case of event is change in the light conditions. This could be caused by movement of the visitors or by some external source of light (lamp etc). Subsequently, the controller should compare the light sensor information together with the temperature sensors information to monitor which case occurs. Multiple photo-detectors are mounted to the body of the sculpture. This photo-detector network provides the controller with the ability to monitor the area around the sculpture and to combine these signals together with the signals from the temperature sensor network.

B. Future improvements

The controller is designed in such way as to accept further types of sensors, such as sound (microphone), vision, tactile etc. It is also possible to connect the controller to other computers via a wireless connection. In this way it is possible to implement different control algorithms and to connect the sculpture to other sculptures in the field. This is the task for the future work.

IV. CONCLUSION

The application of robotics in art increasingly takes its place as it engages with the possibilities of attracting the attention of observers and interacting with them. Such exhibitions, performances and sculptures become an essential part of art experience. The modest but successful beginnings in this area will contribute to the further progress of this art presentation. Certainly the goal is to provide resources and create a *Field of Flowers* (Fig. 8) that perform movements in accordance with the program. However, not so distant and feasible idea is for these flowers to be independently movable, to communicate among themselves and with their environment and contribute to a new sublime experience. Let us remember the performance [11] which describes, in the best way, capabilities of modern robotics.

ACKNOWLEDGMENT

This work was funded by the Ministry of Education and Science of the Republic of Serbia under contracts TR-35003 III-44008 and III-44004, and by the Ministry of Culture, Information and Information Society of the Republic of Serbia, (Program for the Support of Projects in the Domain of Art and Culture).

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