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The Uses of Robots in Nuclear Power Plant and MHRD Initiation for Implementation of Awareness in Robotic Technology in India – Part II.

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Abstract-Japan's earthquake and tsunami of 2011, also called the Great **Sendai Earthquake**, occurred at a relatively shallow depth of 15 miles, meaning much of its energy was released at the seafloor. The massive March 11 earthquake and tsunami had a magnitude of 8.9 knocked out Fukushima Daiichi Nuclear Power Plant's, reactor cooling systems, where workers were battling to prevent radiation leaks and a total meltdown. Instead of human, a robot is used to find the meltdown position of the Uranium reactors in Fukushima. Certain considerations that restrict the use of particular robots are discussed. This paper thoroughly describes the steps taken by the **Ministry of Human and Resource Development** for their initiation for skill development in **Robotic Technology** in India. **E-Yantra** is a project sponsored by MHRD through the National Mission on Education through Information and Communication Technology **(NMEICT)**, New Delhi to bring awareness and development of skills among the students about Robotic technology. IIT Mumbai is conducting e-Yantra Robotics Competition for undergraduate students in Engineering/ Science/ Polytechnic colleges with no registration fee.

Key Words- Atomic Energy, Earthquake and Tsunami, Mini Manbo Robot, MHRD, E-Yantra project, Awareness about Robot Technology in arts, science, and engineering students.

I. INTRODUCTION TO ROBOTIC ENGINEERING

The Ancient Chinese are also known to have created mechanical birds, phoenixes, and magpies. Though made of wood, some of these creations could be made to pretend to eat, chirp, and warble like real birds. The history of modern robotics begins with the Industrial Revolution, which ushered in an era of complex mechanics, and the use of electricity. In 1954, George Devol designed the Unimate, a robotic arm device, the first material handling Robot employed in industrial production work that transported dye castings in an automobile plant in the US, which started its work in 1961.
The 1960s saw the arrival of digitally controlled industrial robots. Robotics became a burgeoning science, large investments were made, and robotics spread to Japan, South Korea, and many parts of Europe rapidly. For example, sometimes robots are the only possible way to accomplish tasks like exploring inside gas tanks and volcanoes or traveling on the surface of Mars.

II. IMPORTANCE OF ROBOTS IN INDUSTRIES

The word 'robot' is a comparatively new one and "Robot" is a man-made machine that can perform work or other actions normally performed by humans, either automatically, or by remote control. Robots can be made to look like humans or animals, but this is not always the case. Industrial robots, for example, do not have a human form at all, but they now do the jobs that human beings had done earlier.

'Robot' is actually a Czech word that means **'slave'**. Two thousand years ago, people tried to build mechanical objects that looked and moved like humans and animals. Such a machine was known as

automation. Today's robot on the other hand, has artificial intelligence and can perform many tasks- but the fact remains that automatons are surely the ancestors of the present- day sophisticated robots. **R**obotics is the science and the study of robots. Robotics is a fascinating new field of study, and a rapidly growing one too, as robots are being used more and more in different fields, including industry, research labs, and even in homes. They are most useful in places and situations where it is dangerous for people to work, like in atomic power plants, diffusing a bomb, or working in mines. Moreover, it is often cheaper and easier to use robots rather than humans- especially for some jobs. Japan was number one in Automobile in 20th and it wants robotics to be for their 21st-century economy **(1).**

In Japan during the year 1928, the Gakutensoku robot was designed and constructed by Makoto Nishimura **(2)**. Japan is still a leader in robotic production. Automation and robotics, are familiar concepts in Japan and it is used either to replace or enhance human labor. Prof. Ichiro Kato of Waseda University initiated humanoid robots WABOT project in 1967 and completed the WABOT - 1 in 1971, the world's first full-scale humanoid intelligent robot with two arms, walked on two legs and sees with two camera eyes **(3)**. Japanese companies are leading in the development of robotic technology **(4)**. FANUC industry, Kawasaki, Sony, and the Yaskawa Electric Corporation have traditionally been at the forefront in robotic development during Japan's economic rise. The main reason for Japan's postwar economic success is automation and the integration of robotic technology into industrial production. Kawasaki started the commercial production of industrial robots over 40 years ago **(5)**. Out of 700,000 industrial robots in worldwide, 500,000 of them were from Japan **(6)**. Japan initiated an eight-year national development program in 1984 **(7)**. This $150m program includes the development and maintenance of robots for the nuclear industry. Japan exported some $1.6 billion worth of industrial robots in 2016 i.e. more than the five biggest exporters like Germany, France, Italy, United States, and South Korea combined. In 2012, between 1,235,000 and 1,500,000 industrial robots were in use **(8)**. Japanese industrial robot manufacturers delivered more than half of industrial robots supplied in 2017.

According to the World Robotics - Industrial Robot Report 2018, Japan is the world's leading manufacturer and exporter of robots in the world. Robots are faster and more efficient at many of these jobs than a human could be. In Japan during the year 2017, around 297,200 industrial robots are at work. After China, Japan had the second-highest installed base of industrial robots in 2017 **(9)** (China with 473,400 units).

III. THE FIRST ROBOTS SENT INTO FUKUSHIMA HAVE 'DIED' (13)

There are six reactors in the Fukushima Daiichi power plant. The explosion of the released hydrogen damaged three reactor buildings and impeded onsite emergency response efforts. The piping facility in the building was destroyed, and the facilities for the external power supply and backup power were destroyed. The fuel rods in the reactors melted through their containment vessels and no one knows exactly where they are now. The earthquake and tsunami that struck Japan's Fukushima Daiichi nuclear power station and damaged the cooling water which is needed to cool the reactors at the plant. The stopped cooling water causes the three of the reactors to undergo fuel melting, hydrogen explosions, and radioactive releases. Radioactive contamination from the Fukushima plant forced to evacuate the people up to 25 miles away and affected up to 100,000 residents, although it did not cause any immediate deaths. [12]. The radioactive contamination can lead to cancer which may change in DNA called by mutation. Fukushima Daiichi plant is so dangerous to humans that Tepco has taken the initial steps to develope robots, which can swim underwater and negotiate obstacles in damaged tunnels and piping to search for the melted fuel rods.

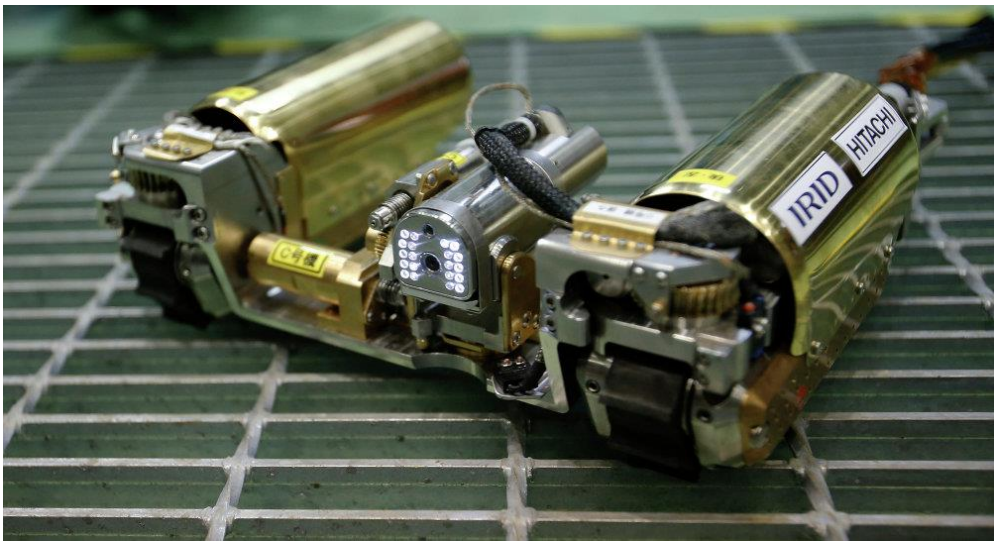

Fig.4: Hitachi Developed a Snake Like Robot for Investigation in the Reactor Core.
Courtesy: Associated Press Photo.

Tepco's head of decommissioning Naohiro Masuda said in an interview, “It is extremely difficult to access the inside of the nuclear plant”. "The biggest obstacle is radiation." No one knows exactly whether the fuel rods melted through their containment vessels in the reactors or not. of the melted fuel rods in the other three reactors at the plant has not been developed so far. Head of the Tokyo Electric Power Company (TEPCO), Naohiro Masuda told in an interview that it is extremely difficult to access the inside of the nuclear plant. Tepco developed a robot that can swim underwater through the damaged tunnels and piping to search for the melted fuel rods. Masuda said that the radiation destroys the wiring of the robot when it enters close to the reactors. Masuda also said that it takes two years to develop a single-function robot [(10)].

The electronics giant of Hitachi developed the snake-like robot, along with GE Nuclear Energy. This robot was ready to examine the damage inside the reactor on April 2015. The robots were designed to swim through the underwater tunnels in order to investigate inside the reactor core of the now-defunct cooling pools. The specially designed remote-controlled robots that were sent into the site of the 2011 meltdown at the Fukushima Daiichi nuclear power plant in Japan have reportedly 'died'. High amounts of leaked radioactive materials had damaged the wires of the Robot.

IV. SCORPION ROBOT FOR INVESTIGATING FUKUSHIMA'S REACTOR

Tepco sent a Scorpion shaped robot to the unit-2 which was jointly developed by Toshiba and the International Research Institute for Nuclear Decommissioning (IRID) [(14)]. It was suspected that the Unit 2 nuclear reactor might have melted and the robot’s mission was to investigate the melted uranium by Scorpion robot. This is the second robot that was allowed to enter the containment chamber of the Fukushima Daiichi nuclear power plant in Japan.

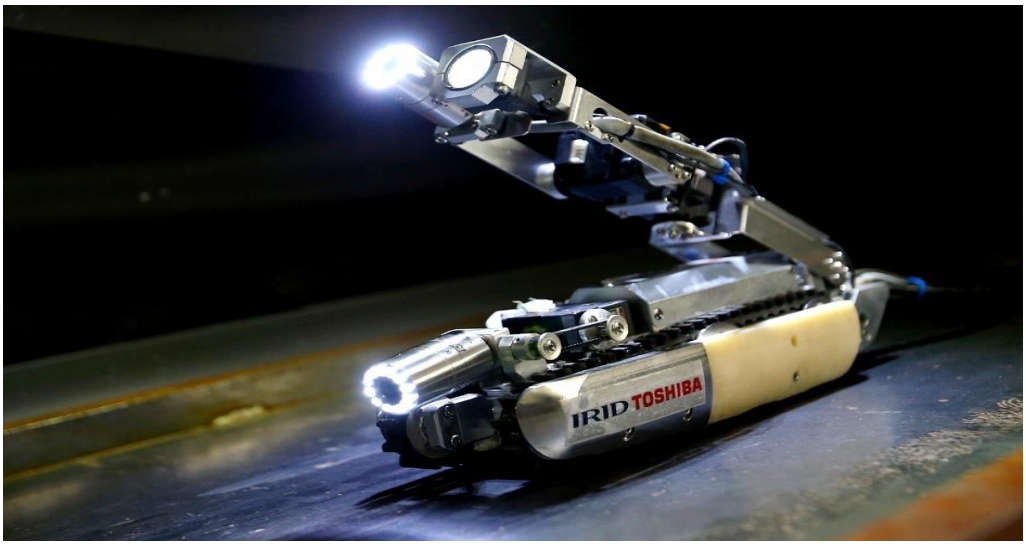

Fig.5: Toshiba's Revolutionary Scorpion Robot to Explore the Fukushima Reactor.
Courtesy: Technocrazed.com

This two feet long robot shaped like a scorpion is equipped with a camera on its front, and another camera on its tail that can whip up and look around. It also sports temperature and radiation sensors. Toshiba and the International Research Institute for Nuclear Decommissioning designed the scorpion robot to scoot on a caterpillar. The "scorpion" robot, can lift up its camera-mounted tail to achieve better viewing angles, is also designed to crawl over rubble inside the damaged facility. But this scorpion robot could not reach its target destination of reactor core through which nuclear fuel is believed to have melted because the robot had difficulty moving, a company spokeswoman said. She said that because of radiation or obstacles, it is not possible to check and clear the debris immediately. Unfortunately, this Toshiba Robot has died in the depths of one of Fukushima's nuclear reactors, as attempts to locate and remove melted radioactive fuel continue.

V. MINI-MANBO (SUN FISH) ROBOT [15]

The scorpion robot had failed, getting caught on debris or suffering circuit malfunctions from excess radiation. The swimming robot shown in Fig.6 was co-developed by Toshiba an electronics and energy giant in Japan and the government's International Research Institute for Nuclear Decommissioning. Scientists want to know the melted nuclear fuel's exact location and understand structural damage. The newer version, of a robot called the Mini-Manbo, or "little sunfish," was made of radiation-hardened materials with a sensor. This Mini-Mambo (miniature sunfish) is a submersible (underwater) robot fitted with radiation-hardened materials and sensors developed to inspect a nuclear plant in Fukushima. The size of this robot is that of a shoe and uses tiny propellers to hover and glide through the water in a manner similar to an aerial drone. It succeeded the previous robots had failed. After three days of careful navigation, the Manbo finally reached the heavily damaged Unit 3 reactor of the Fukushima Daiichi plant.

Fig.6: Mini Manbo (Sun Fish) Robot
Courtesy: Japantimes.co.jp

Fig.7: The Mini-Manbo Robot at a demonstration in Yokosuka, Japan.
Courtesy: The New York Times.

This robot took a video of a gaping hole at the bottom of the reactor. The floor beneath looked like a solidified lava: This is the first image ever taken of the plant's melted uranium fuel. The officials became more confident about managing the disaster, they began a search for the missing fuel. Scientists and engineers built radiation-resistant robots like the Manbo. The director of research and development Shinji Kawatsuma said that I've been a robotic engineer for 30 years, and we've never faced anything as hard as this.

VI. NATIONAL MISSION ON EDUCATION THROUGH INFORMATION AND COMMUNICATION TECHNOLOGY:

In a country like India, where labor is still plentiful, one would think that there would not be much scope for selling industrial and domestic robots. Industrial robots are not a risk to jobs. They are the

only means to increase production. However, as domestic help becomes more expensive, harder to find, and more demanding, people slowly understand the advantage of using robots in industries and houses. Many factories all over the world and India have been using computer numerical control (CNC) machines for the last few years. A computer program with all the instructions has to be fed directly into a mini-computer. After loading as per the program or instruction the operation is done automatically by the CNC machines, which use these instructions to control machinery such as the grinder, milling machine, and lathe. A human-machine interface may eventually make the good old CNC machine voice-activated.

The International Federation of Robotics (IFR), a Germany-based non-profit organization with members from over 20 countries, defines an industrial robot as "an automatically controlled, reprogrammable, and multipurpose machine". Today, people who are trained to handle conventional machines have to learn to handle industrial robots. If humans and robots work alongside, productivity will be higher.

VII. E-YANTRA ROBOTIC PROJECT [16, 17]

A good number of job opportunities are available for robotics engineers both in India as well as in abroad countries. E-Yantra is a project sponsored by MHRD through the National Mission on Education through Information and Communication Technology (NMEICT), New Delhi [16] to bring awareness and development of skills among the students about Robotic technology. IIT Mumbai is conducting E-Yantra Robotics Competition which is open to all undergraduate students studying in Engineering/Science/ Polytechnic colleges in India with no registration fee. A team consists of 4 students' and they form a group and these 4 students need not be in the same branch, but the same institution. The selection is based on an online test, and the selected teams are given a robotic kit [16] with all accessories and video tutorials to help them learn basic concepts in embedded systems and microcontroller programming.

Table-1. Year-wise Data of Students Registered & Finalist Students for e-YRC competition.

Year	No. of registered student	No. of selected team	No. of finalist student
2012	4,000	500	80
2013	6,324	640	80
2014	12,428	1,444	132
2015	15,689	3,076	176
2016	22,608	3,620	148
2017	23,728	4,200	136
2018	28,692	6,176	164

Source: http://www.e-yantra.org/

The team has to solve a given problem in 12-15 weeks by video uploading. The real truth in India is all the engineering college students have limited exposure to hands-on experiments in Robotic Technology. The engineering college students all over the country are capable of working on challenging and interesting projects on robotics, but the lack of lab facilities and mentors have kept students away from projects in embedded systems and robotics. In this E-Yantra, competition students can participate as a team of four**.** The online test is used for team selection to determine the

eligibility of the team to participate in the competition.Table-1 gives the details of year-wise data of students registered and finalist students for e-YRC competition. The real-world problems assigned to the teams as "themes" are then implemented using the robotic kits. The winners of this competition will be eligible for the summer internship at IIT Bombay through the E-Yantra program. The main aim of the e-Yantra Robotics Competition is to train the students in robotic technology [16, 17].
IITB takes various initiatives of the projects as follows [16]:

1. e-Yantra Robotics Competition (e-YRC)
2. e-Yantra Lab Setup Initiative (e-LSI)
3. e-Yantra Symposium (e-YS)
4. e-Yantra Ideas Competition (e-YIC)
5. e-Yantra Resource Development Center (e-YRDC)

VIII. CONCLUSION

The accident caused three of the facility's six nuclear reactors to meltdown. In the Fukushima Daiichi power plant, robots are used for the investigation of meltdown at the reactor. In India, the main reason why robots of today's generation are unable to do this kind of job is that they lack intelligence and emotion which we can see in future robots. In India, the young minds who are interested in the field of robotics can participate in E-Yantra competition which is conducted by IIT Mumbai every year which helps to all Indian engineering students to develop the knowledge and skills in the field of robotics. The skill development in robotic technology through e-Yantra will help the students all over India for equal opportunities and contribution in the field of robotics and they can compete with western countries who are pioneers. This E-Yantra project-based learning is providing hands-on learning to limited engineering students because of limited robotic laboratory facilities for assessment. This project creates very good theory and practical knowledge in embedded systems and artificial intelligence to take challenging problems and providing solutions which are the most wanted subjects in all over the world particularly in europian countries. Therefore, AICTE should make mandatory that all the engineering colleges should have this e-yantra laboratory.

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