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Service Robot Application for Examination and Maintaining of Water Supply, Gas and Sewage Systems

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Abstract— The service robots for examining and maintaining of water supply, gas and sewage systems are very interesting to researchers who are dealing with this field, insomuch a certain number of service robots are applied. According to a statistical analysis it is obvious that their number increases in application year after year. The service robots for examination and maintaining of the pipeline systems are segmented robots equipped with the cycles or tracks for inner flow of oil, gas or wastewater, industrial or air ducting. Additionally, fast problem detecting inside of the tube systems, like failing in welding, corrosion, erosion, breakup, aqueous, loose parts, invalid inner covering etc. They are applied as a substitute to human potential or where human presence is disabled and where moving are difficult. They are also applied where work conditions are dangerous for human, where high temperatures are developed, pressures, and where concentration of the health dangerous materials is present. This paper provides a service robot distribution for examination and maintaining of the pipeline systems. A certain number of the service robot applications are shown here, for controlling and maintaining of the pipelines, sewage systems, nuclear facilities, and working on high temperatures.

Keywords— examination, maintaining, pipeline, robot, service robot, application

I. INTRODUCTION

The service robots, i.e. automated structures can have a wide spectrum of application in situations where human presence is dangerous, problematic or with an inaccessibility problem [1,2,3,4,5,8]. For instance, the service robots are already applied in examination and maintaining, where a human potential is substituted and where human presence is disabled.

They are applied where moving is disabled and difficult, in ground analysing and building of the underground installations and tunnels, in analysing of the magmatic changes in volcanoes and alike. The service robots are also widely applied in examining and maintaining branches where the work conditions are dangerous for the human, where the high temperatures are developed and where concentration of the dangerous materials for human health is present, like manufacturing and melting of metals, glass manufacturing and ceramic products, process of painting under a high pressure, welding, grinding, polishing and alike. This paper provides concrete examples of the service robot application in procedural operations of examination and maintaining of the water supply and sewage systems.

II. DISTRIBUTION OF SERVICE ROBOT SYSTEMS FOR EXAMINATION AND MAINTAINING SYSTEMS

Organizations IFR (International Federation of Robotics), UNECE (United National Economic Commission for Europe) and Organization for Economic Cooperation and Development (OECD) [5,6,7] adopted a preliminary classification system for service robots for examination and maintenance by category and type of interaction, so that service robots for examination and maintenance of the system have the following classification.

Table I: **Classification of service robots for examination and maintaining systems [4]**

PROFFESIONAL SERVICE ROBOTS	
29-31	***Examination and maintaining systems***
29	Premises inspection
30	Inspection of pipes and sewages
31	Other inspections and maintaining systems

The biggest relevant useful factors are: high quality of work and productivity, reduction of manual work, increased safety i.e. risk avoidance, increase of operative usability, temporary flexibility, new, pre-available contents, conditions, etc. Following table shows the estimate of relevance factor for the types of service robots that are implemented in examination and maintaining systems.

Table III: **Estimation of relevant factors of service robots types for examination and maintaining systems [4]**

29-31	***Examination and maintaining system***	***Reduction manual work***	***Safety increase, risk avoid***	***The increase of operative usability***
29	Premises inspection	•	• •	
30	Inspection of pipes and sewages			• •

Table 2 shows estimation of relevant factors of service robot types, degree of relevance with no symbol (*not relevant*) to two dots (*high relevance*). Following figure 1 shows chart with statistical data collected by United National Economic Commission for Europe UNECE and International Federation of Robotics (IFR) which collected data from service robot manufacturer.

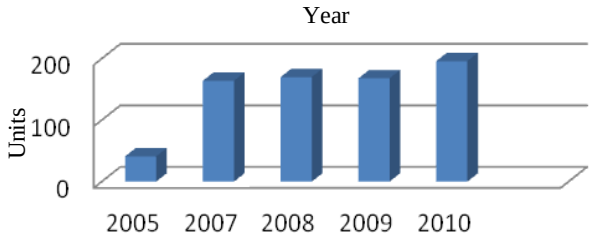

Fig. 1 Yearly supply of service robots for examination and maintaining systems in period 2005-2010 [4,5,6,8]

Based on Figure 1 a it can be concluded that from 2005 to 2010 there was an increase in the application of service robots for examination and maintenance. In 2005 the service robots for examination and maintenance take a share 0,67% of the total number of service robots in that year, whereas in 2010 this percentage amounted to 1,35%. This leads to the conclusion that the annual supply of service robots examination and maintenance is highest in 2010.

III. SERVICE ROBOT APPLICATION FOR EXAMINATION AND MAINTAINING OF THE WATER SUPPLY, GAS AND SEWAGE SYSTEMS

Examination and maintaining of tanks, hoses and tubes are tasks suitable for the robots. Typically, the pipeline robots are segmented robots equipped with the cycles or tracks for inner flow of oil, gas or wastewater, industrial or air ducting. Additionally, fast problem detecting inside of the tube systems, like failing in welding, corrosion, erosion, breakup, aqueous, loose parts, invalid inner covering etc.

The sewage service robots can clean the tubes with a diameter of 200 to 600 mm that are unavailable for human. They are usually based on a multi-segmented platform. The service robot PatrolBot of a MobileRobots company (SAD) [7,8, 9,11] supervises warming, ventilation and air conditioning effective, without costs and risks. For instance, taking care of an air quality, radiation and fume, it ventilates a building and checks the damage of the distant building sites. The MIMROex service robot of the Fraunhofer IPA Company is a prototype of a new generation of mobile robots used for inspection and maintaining in risk locations, especially fuel oil from a sea and in a manufacturing gas surroundings.

It has been equipped with a robotic hand, caring a camera for a visual inspection, and different kinds of sensors, like microphone, gas, fire sensors and laser scanners. A figure 2 below shows especially capable Snake arms of the OC Robotics (UK) for accession and investigation of the enclosed spaces. These robots have more serial conjunctions which are different from the conventional robots.

They do not possess notable joints. According to this, a whole device can track where a top of the robot is going. An examination and maintaining is carried out for the systems where human presence leads to catastrophic health consequences. Such facilities are chemical and nuclear facilities. In nuclear facilities the examination and maintaining has to be carried out, or innovations due to the exposure of a worker to a radiation. In these situations different service robots are used. One of such service robots is shown in figure 2. Servo-manipulator ASM.

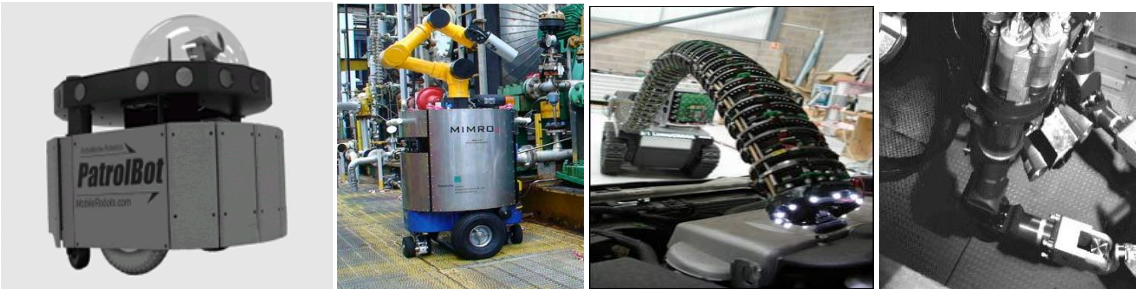

Fig. 2 The service robot PatrolBot, MIMROex, Snake arms and Servo-manipulator ASM [8, 9]

The service robots for examination and maintaining of the systems under a high pressure and high temperatures where human presence is not possible are developed; an example of such robot has been given at figure 3.

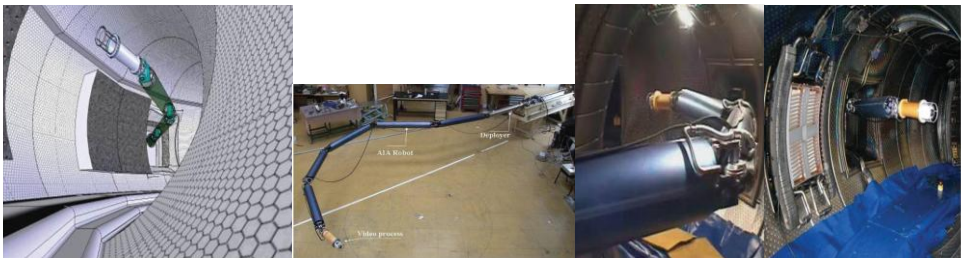

Fig. 3 The service robot-snakelike for examination and maintaining of the facilities under a high pressure and temperatures [8]

A laboratory for the (DOE/NETL) technology, Carnegie Mellon University (CMU), with a support of the Gas company (NGA), has designed the service robot system of a new generation Explorer-II (X-II) [8,11], enabled to work under a pressure, examination and control of the gas pipeline. The electronic architecture enables through the GPS to track a location during the control of the pipeline damages, and quickly undertaking interventions in order to correct the damage. The service robot named the train robot has been made of the modules shown at figure 4.

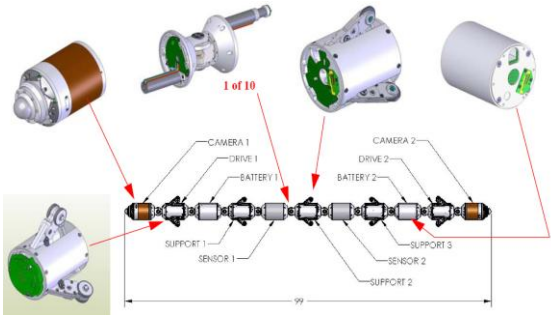

Fig. 4 Service robot Explorer – II (X-II)

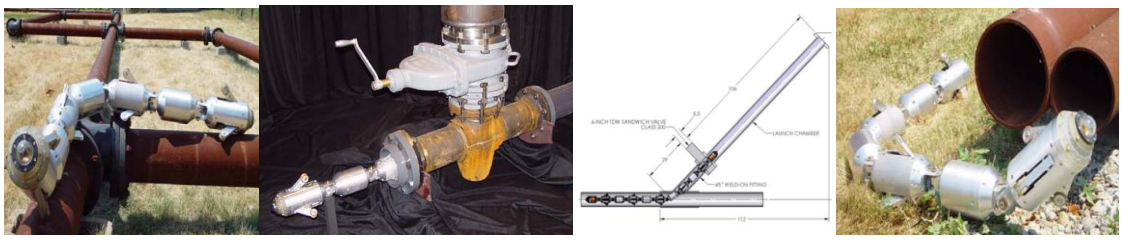

Fig. 5 Application of the service robot Explorer-II [8,11]

The service robots Explorer-II are practical for control of all kinds of pipelines due to its ability to move easy through the pipeline, and also possess flexibility for the pipelines under an angle, like it is shown at figure 5.

Another robot for the pipeline examination is MARKO plus robot. This service robot is extraordinary mobile, and like a snake, moves through the tubes with its flexible body.

Fig. 6 The service robot MARKO plus during the examination of the rainfall canals

The body segments contain two batteries for energy supply, a RC 104 computer, two symmetric heads and two connections for the operation elements. The PC 104 module enables robot to move self-willed. The ball joint has three variation rates and is placed between the drives. A highly integrated electronics uses a digital signal of the processor which controls an engine and gives exact angle calculations.

Large electronic energy manufacturers want to be competitive on a market. Their goal is to prolong a generator's working life, also to turbines, boilers and compressive lines. It can be achieved only through the examination of the aforementioned equipment, by detecting of imperfections on time and fixing the damages. Until now, it has been carried out manually by the experts of that field. During the last few years, with the development of the robotic technology, it has been carried out by the service robots that perform measures, painting and scanning of the areas. The advantages are huge due its possibility to examine even those areas which are inaccessible to human. Unlike the human, the service robots are insensible to high temperatures, dust and other unfavourable conditions. For these examinations, the AIR service modular robot is available, shown at figure 7.

Fig. 7 The AIR service modular robot in the control process of an impeller [14]

The AIR service robot is reliable for the examination of corrosion, breaches and other imperfections, and with finding them a severe damages can be avoided. Different sensors can be fitted on the AIR robot, and cameras which can be integrated in robotic navigation system.

IV. CONCLUSIONS

Examination and maintaining of tanks, hoses and tubes are tasks suitable for the robots. Typically, the pipeline robots are segmented robots equipped with the cycles or tracks for inner flow of oil, gas or wastewater, industrial or air ducting. Additionally, fast problem detecting inside of the tube systems, like failing in welding, corrosion, erosion, breakup, aqueous, loose parts, invalid inner covering etc.

The sewage service robots can clean the tubes with a diameter of 200 to 600 mm, which are unavailable for human. They are usually based on a multi-segmented platform. The service robots are also widely applied in examining and maintaining branches where the work conditions are dangerous for the human, where the high temperatures are developed and where concentration of the dangerous materials for human health is present, like manufacturing and melting of metals, glass manufacturing and ceramic products, process of painting under a high pressure, welding, grinding, polishing and alike.

The sewage service robots can clean the tubes with a diameter of 200 to 600 mm that are unavailable for human. They are usually based on a multi-segmented platform. A suitable platform of the RedZone Robotics (SAD) is performing inspection and rehabilitation tasks in tubes with a diameter of 900 to 1.250 mm, or more. A huge diversity of different systems for inspections and sewage correction has been recommended and introduced to the market. Usually, these systems are telecontroled with tracking or rolling of the mobile platform and camera transmission, sensors or with simple tools.

The majority of the existing inspection systems for tanks, hoses and tubes are adapted to solutions. The other systems are developed in order to examine the ventilation holes and air system tubes. The service robots for examination and maintaining of the pipelines for any medium (water, gas, fuel, oil etc.), sewage systems, nuclear facilities or work in aggressive areas are in an expansive phase of examination and concrete task application. A great development of these service robots is expected in the future and their bigger application.

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