Robotics

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1.1 Introduction

Artificial intelligence is a branch of computer science that deals with the building of smart automatic machines that is capable of performing tasks that typically require human intelligence. There are many branches of Artificial intelligence that are crucial in today's time. Some of these branches include: Machine learning, Expert systems, Neural network, Fuzzy logic and much more. One important field in Artificial Intelligence to deeply discuss in this article is the study of robotics engineering.

Robotics is the engineering and technology for constructing, designing, and implementing autonomous and semi-autonomous machines that perform tasks typically done by humans; a substitute that is used instead of humans to perform certain tasks. The man-made machines, called robots, are composed of Electrical, Mechanical, Mechatronics and software engineering which are explicitly programmed using high- level languages, such as C++ and Python that imitate human actions. These computer-controlled machines are programmed to move, manipulate objects, and perform actions that they are programmed for. Each robot made has a different level of autonomy; Some are fully controlled by humans, in which they executes tasks ordered by humans, or, they can be fully autonomous, meaning that they perform task without any external influence or commands.

These machines can be used everywhere to handle jobs already done by humans, such as in industrial factories, consumer factories, medical fields where they are used to perform real medical operations and surgeries, in transport, laboratory researches, weaponry, code analysis and also can be used in space explorations. The use of robots became extremely vital in the current era, in which they became used everywhere and at all times for many purposes. One important purpose of using robotics in our daily life system is to do repetitive actions considered to be dangerous to humans, such as working in factories, explorations of bombs, in hot and hazardous environments, and in other risky conditions that can be life-threatening to humans. The use of robots is basically a substitute of a human needed to conduct these kind of tasks considered to be at very high risk to be actually performed by a human being.

1.2 A Brief History

At the end of the 20th century, robots were not part of that

from the well-known and popular science. It wasn't until 1917 when

Joseph Kabek wrote the short story Obelek in which he described car brushes, and in 1921 when his brother Karel Kabek wrote the play.

Rossum's Universal Robots (RUR) states that the concept of robotics has entered the popular consciousness. As an initial idea

The term robot was originally coined and is a topic of discussion in

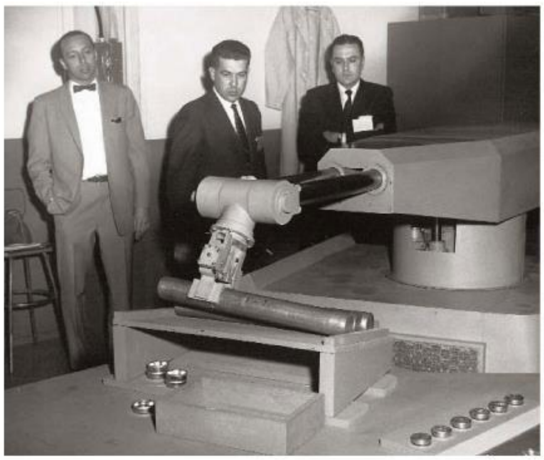
The world of Czech literature. The term robot is derived from

The Czech word robot means serf or labourer.

The reason for the emergence of robots is that they do the same work as humans, but with high accuracy and less potential for error. Of course, the old robots were used in many fields, and the types of robots differed in the past, for example: the military and medical fields and traffic regulation, and as we learned in the first chapter, one of the American projects is the automatic military vehicle

And the system of experts to assist pilots in the military field during 1985-1981, and of course the first robot to perform his name is arthrobot surgery in 1983, and of course robots are used in the industrial and scientific sectors, for example, bomb detonation and dismantling experiments.

And the development in the fields of robotics continued to the extent we have reached now...



1.3 Modern Robotics

Further advancement in technologies and research has led to the development of smart automated manipulators and artificial intelligence. Automated robots and semi-automated robots have replaced manual repetitive labor, dangerous tasks and other intolerable and complicated work that humans find it exhausting, difficult or time consuming to do.

Nowadays, smart robots are used to manage and carry out different tasks; these include using them in factories were they can manufacture and assemble parts, in space explorations to explore and sensor the surfaces of different planets, and most importantly, they are widely used in the medical field where they tend to conduct severe surgeries or as an aid for doctors. These advanced machines are programmed and assembled by Artificial intelligence. Artificial Intelligence, or AI, is a computer program that is programmed to evaluate a situation and take action in order to achieve a predetermined objective. Software capable of preventing identity theft, generating appropriate search queries for search engines, and cracking ciphers for the FBI has recently been developed. When it comes to the future of robotics, AI would almost certainly play a significant role. On-demand video Predictive analytics is now used by Netflix and Amazon Prime to suggest genres and shows to audiences. Customer satisfaction is improved by algorithms that cluster suggestions based on display similarities. Businesses are now likely to employ sentiment analysis tools to gain a more in depth understanding of consumer perceptions of their goods and services. This aids companies in better marketing to consumers.

1.4 Use of Robotics in the Medical Field

Introducing the robotics technology in the medical field has been accepted as a smarter, advanced and an efficient tool in healthcare. Several advantages of those automated machines being fatigueless and active at all times has been broadly acknowledged in healthcare, where they serve and execute medical procedures effortlessly, accurately, reduces time and possible errors. From their precise and efficient functionality, robots are becoming more trustful in many risky duties than ordinary workers; by making medical procedures safer and less costly for patients. The capacity to alter robotic intervention manipulation interactively has been a key factor for patient safety.

The medical side has launched various types of robots used on daily basis to perform intense surgical procedures. One of the many types are the surgical robots. Various highly articulated robotic manipulators have been challenged to reach parts of the human body that are difficult to reach. One example is the ‘da Vinci’ robot, approved by the FDA in 2000 that is said to have conducted over 6 million surgeries worldwide, that is controlled by the surgeon from a console. This surgical robot focuses on a myriad of surgical procedures in urological, bariatric, and gynecological surgical procedures. Many companies are developing robots that are responsible to perform specific operations in a specialized field, such as knee or hip replacement. Others are seeking to build systems that incorporate artificial intelligence to assist surgical decision-making. Modus V is an example of AI integrated automated arm and digital microscope that is responsible for tracking surgical instruments, moves and works to the area that the surgeon is working on, and projects a magnified, high-resolution photos and x-rays on the screen. The surgical robots is now the market leader, in which their use has increased significantly by 32% from 2017 up to today. Another type of robots used in health care are called Exoskeletons. Powered exoskeletons are wearable mobile electromechanical robots that has been developed as augmentative devices used to enhance the physical movement of the wearer or allow limb movement with increased strength and endurance and aid quick recovery. For example, Cyberdyne’s Hybrid Assistive Limb (HAL) is an exoskeleton, which has sensors placed on the skin to detect small electrical signals in the patient's body and respond with movement at the joint. These devices are designed to help patients recover from conditions that lead to lower limb disorders, such as spinal cord injuries and strokes. From their smart and responsive designs, these devices are very expensive that can cost up to $1000 of monthly rental, but they are indeed very supportive of the physical motion of the human body.

Another type of robots that are responsible to provide care and help out elderly and disabled patients is currently at very low of use, but should increase significantly in the next decades since the number of nurses available are not enough for every patient existing at a particular hospital. These robots are relatively simple; such as helping people get into and out of bed, deliver food, reminding patients to take medications, and do other simple tasks that are usually performed by nurses. Another use for these robots is to help out and assist nurses with the multiple repetitive tasks done by them on an hourly basis.
These include: taking blood, recording temperature, provide hygiene and treatments to the patients. This type of assistance is simple yet saves time and allows nurses to focus on individualized patient care and devising treatment plans.

1.5 Algorithms in Robotics

Why algorithms are used in robotics?

To tell the robot how to respond to certain situations and to make efficient use of hardware and software.

In general, there is two types of algorithms used in a team robotics:

1- Centralized Algorithm: (play the role of manager or admin)
Every process sends a request to the central algorithm

- **Advantages:**
  - Every process has to be done and end no starvation.
  - Easy to implement only 3 operations only (request, grant, release).

    - Used for more general resource allocation rather than just managing critical regions.
- **Disadvantages:**
    - If the Admin or manager made one mistake it will let all the system fail.
    - In a large system a single admin or manager cannot handle all the pressure and complexity.

2- **Decentralized algorithms**: here each robot makes its own decisions based on observations and learning.

- **Advantages:**
  Process can be done or end without waiting for permeations.
  One error or mistake won't let all of the project to fail.
- **Disadvantages:**
  Having more pressure on a single robot.

Algorithms used in single Robotics:

1- Dstar Lite:

Dstar Lite is a pathfinding algorithm that allows the programmer to find the optimal path between a starting point and an ending point in a known or partially known environment. This algorithm was designed to be run on a graph data structure.

This **algorithm** can be used in conjunction with a sensor array to dynamically avoid obstacles while the **robot** is moving.

2- Q-learning algorithm (quality learning):

The point here is to let the robot learn from its old mistakes and never do it again there is 6 steps to represent this algorithm.

Which have a 6 steps:

i. Observation of the environment.
ii. Deciding how to act using some strategy.
iii. Acting accordingly.
iv. Receiving a reward or penalty.
v. Learning from the experiences and refining our strategy.
vi. Iterate until an optimal strategy is found.

3- localization algorithms:

The main purpose of **localization algorithms** is to define the position of (parts, nodes…etc.). The more the estimated locations are close to the real locations, the more the used algorithm is considered successful and effective, it's used in sensors in robots.

4- Deterministic selection algorithms :

This algorithm helps robots with selection between a lot of options with more fast time and less complexity with O(n).

5-Dijkstra algorithm:

This algorithm helps robots finding **the shortest paths between nodes in a graph or in a road or in a network.**

We would like to explain more about the Dijkstra algorithm since its used in real life time now like in Google maps and in gaming.

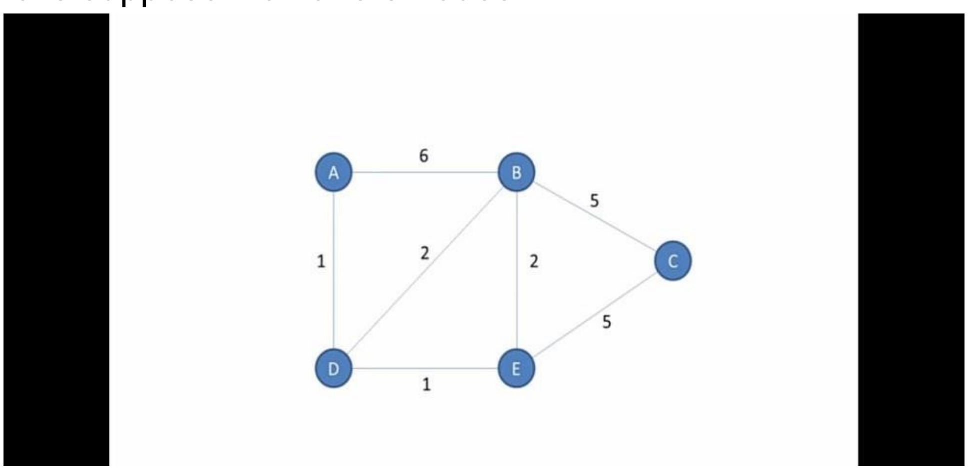
Pseudo code:

```
function dijkstra(G, S)
    for each vertex V in G
        dist[V] <- infinite
        prev[V] <- NULL
        If V != S, add V to Priority Queue Q
    dist[S] <- 0

    while Q IS NOT EMPTY
        U <- Extract MIN from Q
        for each unvisited neighbour V of U
            temperoryDist <- dist[U] + edgeWeight(U, V)
            if temperoryDist < dist[V]
                dist[V] <- temperoryDist
                prev[V] <- U
    return dist[], prev[]
```

Now let’s explain how the algorithm works

let’s suppose we have 5 nodes



A,B,C,D and we want to find shortest path from A to C

So we start from the head point A and give it a distance of zero and set others to infinity because we still don’t know the distance so we can know the point (node) is done we have to make it visited [i]=1 now we check paths we have 2 path to B and to D distance to B =6 distance to D =1 and visited [i]=1 now we check connected path to D which is distance 2 through B and 1 to E now we take min distance which is E now visited[i]=1 here we have 2 path with distance 2 to B and 5 to C min is B but B is visited[i]=1 so we check C and we got the Goal with distance 7 which is shortest path A-D-E-C.

We take min distance which is 1

```
#include "stdafx.h"
#include<iostream>
#include<stdio.h>
using namespace std;
#define INFINITY 9999
#define max 5
void dijkstra(int gr[max][max], int n, int st) {
	int co[max][max], distance[max], pred[max];
	int vis[max], count, mind, nxt, i, j;
	for (i = 0; i<n; i++)
		for (j = 0; j<n; j++)
			if (gr[i][j] == 0)//set all empty nodes to inf (we still dont know
the distance )
				co[i][j] = INFINITY;
			else
				co[i][j] = gr[i][j];
	for (i = 0; i<n; i++) {
		distance[i] = co[st][i];
		pred[i] = st;// set all preveous nodes as he start point
		vis[i] = 0;// set the vis point to zero no point had been vis yet
	}
	distance[st] = 0;// set distance for start 0
	vis[st] = 1;// since we had used the distance the node is visited
	count = 1;

	while (count<n - 1) {
		mind = INFINITY;
		for (i = 0; i<n; i++)
			if (distance[i]<mind && !vis[i]) {
				mind = distance[i];
				nxt = i;
			}
		vis[nxt] = 1;

		for (i = 0; i<n; i++)
			if (!vis[i])
				if (mind + co[nxt][i]<distance[i]) {
					distance[i] = mind + co[nxt][i];
					pred[i] = nxt;
				}
		count++;
	}

}
int main() {
	int gr[max][max] = { { 0,3,0,1,10 },{ 1,0,4,0,0 },{ 0,6,0,1,1 },{ 5,0,2,3,6 },{
8,0,1,4,0 } };// set of nodes
```

```
        dijkstra(gr,max, 0);
        return 0;
}
```

1.6 Other Types of Robots

Generally, there are 5 main types of robots, these include:
1) Pre-Programmed Robots: which are robots that operate in a controlled environment, where they being told what to do ahead of time and then simply executing that task.

2) Humanoid Robots: humanoid robots is a robot with its body shape built to resemble the human body. These robots usually perform or mimic human-like activities, such as interacting with human tools and their environments. Two of the most famous humanoid robots are Hanson Robotics called Sophia and Boston Dynamics’ robot called Atlas.

3) Autonomous Robots: A type of robot that operate independently and doesn’t require any human instructions. These robots are designed to carry out tasks in open environment where human supervision is not required. They're one-of-a kind in that they use sensors to perceive the world around them, then use decision-making structures (usually a computer) to determine the best next step based on their data and mission. Roomba Vacuum cleaner is one example that roams freely to clean a house.

4) Teleoperated robots: Teleoperated robots are semi-autonomous robots that can be controlled remotely via a wireless network. These robots are typically used in remote locations with extreme weather, conditions, and other factors. Human-controlled submarines were used to repair underwater pipe leaks during the BP oil spill, and drones were

used to detect landmines on a battlefield as examples of teleoperated robots.

5) Augmenting robots: This type of robots is the most helpful and mostly used nowadays. The field of robotics for human augmentation is a field where science fiction could become reality very soon. These robots are in charge of enhancing a person's existing abilities or replacing those that have been lost. Because of the high demand for people with disabilities, this field of medicine has become well-known. These robots became a part of humanity because they were a replacement for their loss. These enable humans to achieve their full potential. Some examples of augmented robots are robotic prosthetic limbs and exoskeleton robots.

1.7 The Manufacturing Process of Robots

The way a robot is manufactured greatly depends on the complexity of that robot, either has high complexity or performs simple tasks. A common robot is made up of 4 main things, which includes: The actuator (motor, servos, etc), sensors, controllers (the control system) and the power source. To construct a real functioning robot, there are several mandatory processes that are required to follow to implement what is desired. The first process is setting the intention, which is basically setting the main functionality of the robot that is about to be manufactured. Whether its autonomous or not? Will it work in factories? Will it work in hazardous environments? Is it in-home companion? Is it human friendly? This step leads to the designing phase. In this phase, main factors of the manufactured piece must be accounted for in the design. These include: the main job the robot is required to perform, speed of operation, environment of operation, materials involved, length of reach, path of travel, process variables, human involvement or not, level of autonomy , level of complexity, controller capabilities and expected results of failures. This phase also includes how the robot will look like, whether it’s legged robot or a humanoid or etc. The nextstep is choosing the platform of the robot, which includes the operating system the robot will run on and as well as choosing the suitable programming language to program a code the robot is expected to compile. Choosing the best operating system depends whether the person is building an industrial or cognitive robot. Because of its integration with Microsoft's AI solutions, Windows 10 outperforms Linux for robots meant for everyday usage. Furthermore, Windows 10 is user-friendly and simple to operate even for those with very rudimentary computer skills. Once the type of robot to build is selected, the appropriate operating system that best brings the robot to life can be chosen. The arguably most major step in assembling a robot is building the robot’s central command unit, the microprocessor that acts as the “brain” of the robot. Any commands the machine wants to perform, will be authorized and implemented by the brain. This serves as the backbone that supports the robot’s desired features, whether it’s voice cognition, speech, facial recognition, motion detection, or another capability. This "brain's" base might be as simple as a piece of handheld, Internet-connected technology. Raspberry Pi, an inexpensive minicomputer that you can program yourself, and LattePanda, the first maker board preconfigured with a full Windows 10 operating system, delivering the same user experience as a standard Windows PC, are two popular variations. The LattePanda is a palm-sized, Intel-based, Arduino-enabled CPU for robotics prototypes that optimizes, develops, and customizes coding. The good news is that LattePanda isn't just for software developers; its step-by-step lessons can also be used by educators and crafters. The final step is creating the shell. The physical attributes that your robot requires will be dictated by the functionality that you defined in Step 1. If you're making a cleaning robot with vision, for example, the brain must be compatible with a laser scanner, motor drivers, and touch sensors. This step also includes the building of the robot; assembling and connecting parts, sensors, the brain, and everything else related to the development of the robot.

Conclusion

The engineering of mechanical programmed manipulators, called robots is one of the most vital technologies used in today’s world. These devices affected our world both positively and negatively; positively in which they are used in industry to enhance performance rate and conduct efficient, error-free work, and negatively in which decreased employment rate and replaced manual work to automatic handled jobs by them. The engineering of robotics indeed changed our world.