International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

Introducing Robots without Creating Fear of Unemployment and High Cost in Industries

N. Keerthi Shravani
UG Student, MED, CBIT, Hyderabad
Sri . BVS Rao,
Asst. Professor, MED, CBIT, Hyderabad

ABSTRACT:

Robots are desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition, and they cannot be distracted from the task at hand but introducing and installing robots in industry involves huge expenditure and also creates fear of unemployment in industry.

This paper is to suggest ways to overcome the prominent issues by introducing cobot in place of robots in the and gives an analysis on the use of different cobots in the industries with varying domain functions.

1.COBOT AND COBOTICS:

A cobot is defined as a robot that has been designed and built to collaborate with humans. Cobotics is a neologism formed by the collaborative and robotics terms. A cobot can also be considered as a robot intended to physically interact with humans in a shared workspace. A workstation including a robot and a human collaborating is called a cobotic system.

They were invented in 1996 by J. Edward Colgate and Michael Peshkin, professors at Northwestern University. Cobots resulted from a 1994 General Motors initiative led by Prasad Akella of the GM Robotics Center and a 1995 General Motors Foundation research grant intended to find a way to make robots or robot-like equipment safe enough to team with people.

Cobots can have many roles from autonomous robots capable of working together with humans in an office environment that can ask you for help to industrial robots having their protective guards removed as they can react to a human presence

2.INITIAL SETUP:

Building collaborative robots takes two simple steps.

STEP 1: Choose a basic robotic platform, there are multiple options for the basic robotic platform. Vendors have varying capabilities starting from providing robot platform along with SDK (Software Development Kit) to train and teach robots

STEP 2: Programming it to do multiple tasks in a shared space with humans by adding intelligence, through multiple technology options as listed in the table below.

Table 1 : Intelligence Capabilities and Enabling Technologies

Intelligence Capabilities	Enabling Technologies
Dexterity, Self-learning, Autonomous, Interaction with surroundings, machines and humans, Location awareness, Perceive and respond.	Artificial Intelligence, Deep Learning , Object detection, Multi-Sensors/Actuators, Depth Sensing , Gesture recognition, Speech to Text - Text to Speech, Computer Vision Technologies

3.ACCESSORIES:

3.1 Teach pendant: In this case, the teach pendant is very user friendly, with a wide screen that includes a lot of functionality and one simple button (e-stop). All the programming can be done on the fly by simply using the teach pendant.

3.2 Tool: Most collaborative robots are fitted with small grippers or tiny tools to fit lightweight applications. This means that the tools are usually less expensive than ones used with industrial robots

3.3 Safety guarding: Depending on the technique used; we will need either classic fencing with a safety switch/door and a safety PLC to monitor all of this OR we can add light curtains and a vision system that can monitor the presence of humans in its environment..

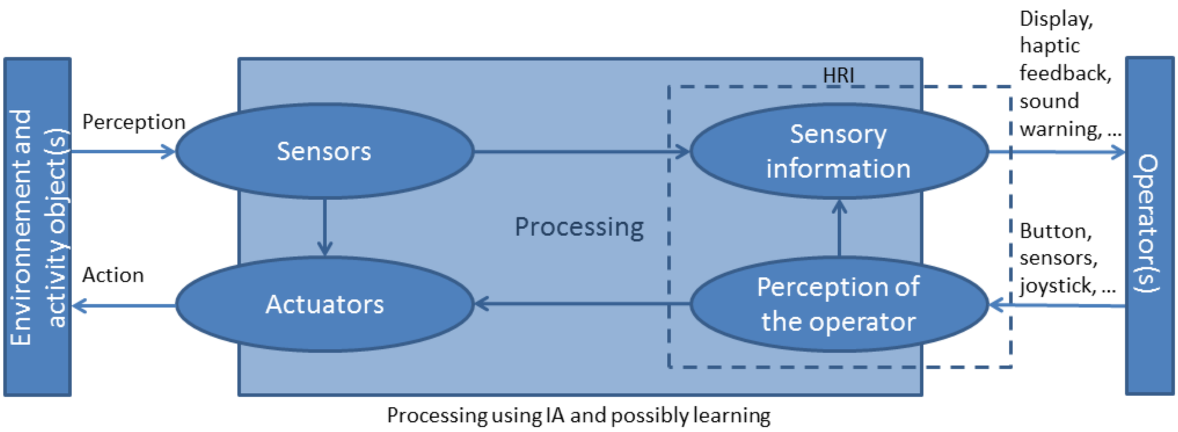
3.4 Robot tool: Then to achieve the task we will need a tool. This tool can be electric or pneumatic since most industrial robots are equipped with integrated air hoses.

3.5 Other accessories: Jigs, conveyors, ordering systems, cameras, lasers and other devices that will help you achieve your application are often required.

4.WORKING OF COBOTIC SYSTEMS:

Cobots are software-defined virtual surfaces and control mechanisms which constrain and guide the motion of the payload. A virtual surface is in many ways analogous to the straight edge in drafting. Drawing a freehand straight line is difficult and slow. The use of a straight edge has the effect of removing a degree of freedom from the pencil, enabling the task to be accomplished quickly and easily. Similarly, a cobot virtual surface removes one or more degrees of freedom from the motion of the payload. This allows the operator to concentrate effort on the remaining degrees of freedom, accomplishing tasks more quickly and with greater precision. Cobots have several advantages over fully autonomous robots, especially when the sensing tasks are very difficult. Cobots take advantage of the sensory perception and spatial awareness skills of a human operator.

4.1 PERCEPTION OF COBOTS:



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5.TYPES OF COBOTS:

5.1.UNICYCLE COBOT:

This is the simplest possible architecture of a cobot consisting of a single wheel steered by a motor (Refer fig1). The cobot is able to demonstrate the two essential control modes: *free* mode in which the wheel is steered such as to comply with the user's desired direction of motion, and *constraint tracking* mode in which the wheel is steered such as to confine the user's motion to a software defined guiding surface.

5.2. SCOOTER:

This is a three-wheeled cobot that resides in a plane like the unicycle device as shown in fig 2, but is allowed to rotate and thus has a usable three-dimensional task space. In free mode, Scooter can allow arbitrary motion in three coordinates: x, y, and theta. Scooter can also display software-defined guiding surfaces which are one or two dimensional .

Two modifications of this cobot have been reported:

(a) a learning cobot

(b) a pallet jack cobot.

An easy and efficient method to define a good ideal path is the focus of the learning cobot. A path optimal to one person may not be optimal to another due to different personal preferences and physiques. A teach pendant is used to define the ideal path. The scooter hence learns from its operator what the ideal path is defined.

5.3. PALLET JACK SYSTEM:

A Pallet Jack system typically does not have more than one steerable wheel (mechanically linked to the handle) and has no automated docking or path tracking modes as shown in fig 3. The addition of a handle to the Scooter is for the purpose of investigating what intelligent three wheel steering modes and automated docking and path tracking modes might be advantageous. And there’s a transition between a free mode and a constrained mode .This cobot uses three revolute joints coupled by three CVTs in the base. It consists of a two degree of freedom parallelogram linkage allowing motion in a vertical plane. This linkage (vertical plane) is allowed to rotate about a vertical axis, thus providing a third degree of freedom. All three degrees of freedom are coupled via revolute joints to spherical continuously variable transmissions (CVTs), which in turn are coupled to a single common power wheel. The contribution of the arm cobot is its ability to create virtual paths and virtual surfaces in a large region of x-y-z Cartesian space.

5.4. DOOR UNLOADER

This is a scooter-like cobot at General Motors (refer fig 4) . This passive cobotic tool takes doors off of vehicles. It consists of a cobot module to control motion across the plant floor and a task specific tooling module to grasp and lift the door off. The removal process is a problematic one due to tight tolerances, highly curved body surfaces, and the need for vehicle specific escape trajectories to avoid damage to any surfaces visible to customers.

5.5. A HIGH PERFORMANCE 6-DOF HAPTIC COBOT

This is a six-degree-of-freedom input device for use with teleoperated robots. A parallel kinematic design and the use of continuously variable transmissions provide high stiffness indirections that would violate a virtual constraint. At the same time, smooth motion is permitted tangential to virtual constraints and in open space. High quality constraint surfaces having one to five dimensions can be displayed. A notable feature of this device is the mutual coupling of all six linear actuators to a common rotating cylinder as shown in fig5. The resulting mechanism is simple to control, and allows new control strategies in Cobotic haptics. The Unicycle Two-Link Arm (UTLA) is a one-wheeled, two DOF cobot that consists of two links and two rotational joints connected to a fixed reference frame. Located at the end of the second link are a handle and a wheel that supports the cobot. There is a force sensor located beneath the handle. This is used for rehabilitation purposes

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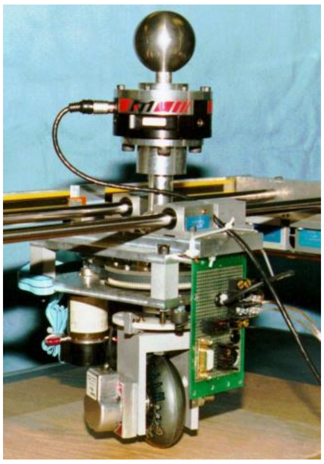

fig 1 : Unicycle cobot

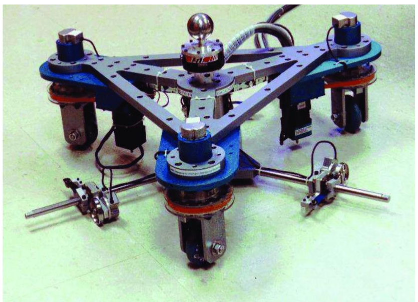

fig 2 : Scooter

fig 3:Pallet jack system

fig 4: Door unloader

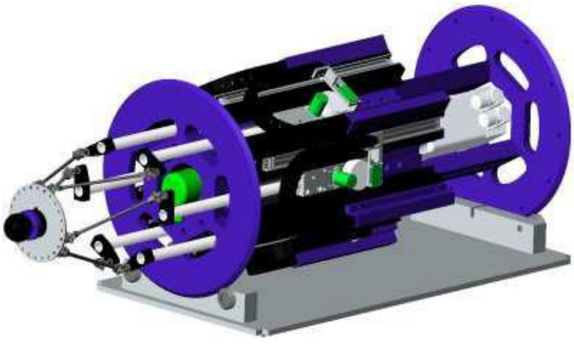

fig 5 : 6 DOF Haptic cobot

6.ROBOTS VS COBOTS:

6.1. PRICE:

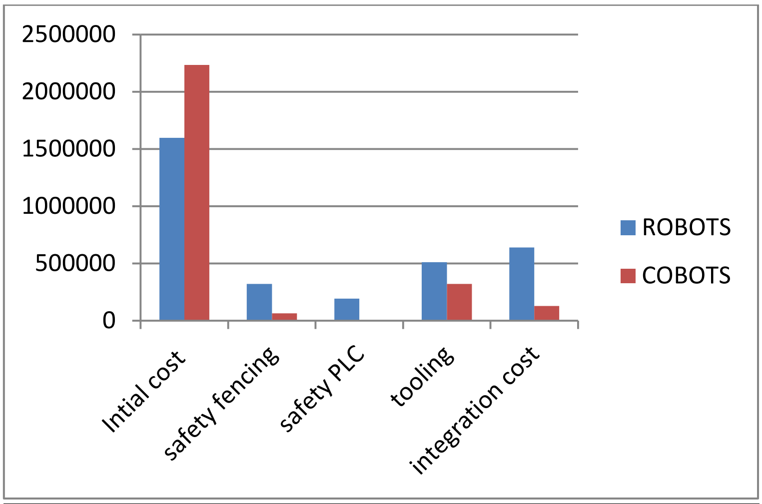

Fig 6. SCALE: x-axis : 1unit = 1 rupee

The initial cost of the cobot might be slightly high compared to robot but the maintenance and installation cost of the robot considerably higher than that of cobot.

6.2. BUILD:

Fig.7 Typical Cobotic System

Fig.8: A Typical Robot used in industry

The robot is generally designed to perform a specific task and its difficult to change the task of the industrial robots without extensive programming and the change in build.
Whereas in cobots its easier to shift from tasks because of its multitasking capabilities and ease of operating.

6.3. PROS AND CONS:

Table 2. COBOT:

Pros	Cons
Can typically share a workspace with employees	Risk assessment is required to define need for safety measures
If no safety cell is required, initial cost of integration and production floor disruption are reduced	Safety precautions can result in very low operating speeds or multiple stops if human is detected in work cell. Other required safety precautions can significantly increase integration costs.
Relatively simple to program and integrate	Limited reach, payload, speed and accuracy
ROI typically in less than a year	

Table 3. INDUSTRIAL ROBOT:

Pros	Cons
Much faster and more accurate than a human, even with high payload	High speeds and throughput may not be appropriate for lowvolume processes
Fully automated production lines can handle applications that are not conducive to humans at speed, removing operators from unsafe or unclean environments	Fixed work cells may require changes to production floor layout
Programming is intuitive and powerful, with extensive integration options	More difficult to change processes, which can add costs if outside resources are required
ROI is defined and usually achieved in 12-18 months	May require specialized personnel or outside resources to set up, program and maintain
Can be implemented in collaborative applications with appropriate risk assessment	Robot can be similar in initial cost to cobot, but if a safety cell is required, it adds system integration costs

6.4. INVESTMENT:

Table 4. Differences between cobot and robot

Cobot	Industrial Robot
Quick set up (less than a day)	Setting up takes days or over weeks
Weighs as little as 11 Kg for 3kg payload.	Weighs around 250 Kg for 3kg payload.
Easy to program without special skills Use of logical process steps and using intuitive tools. Anyone who can work on a smart phone can use this.	Need for a robotic programmer to be hired which might require additional investment
Requires less floor space.	Requires large and separate enclosures
Can work side by side with a human worker because of the built in force sensing technology	Requires safety fencing between the robot and the human worker.

7.NEED FOR COBOTS:

For small to medium industries, any gain in productivity can have an enormous impact. Automation offers significant advantages, but many small and medium sized enterprises (SMES) believe that robotics is out of their reach. These organisations cannot afford large, complex robots that do not fit within their limited floor space that require specialized personnel to program and maintain them, and that are simply too expensive, with poor payback period .

Table 5 : Employment in MSME

Sl. No.	Year	Total Working Enterprises (in lakh)	Employment (in lakh)	Market Value of Fixed Assets (₹ in crore)
I	II	III	IV	V
1	2006-07	361.76	805.23	868,543.79
2	2007-08#	377.36	842	920,459.84
3	2008-09#	393.7	880.84	977,114.72
4	2009-10#	410.8	921.79	1,038,546.08
5	2010-11#	428.73	965.15	1,105,934.09
6	2011-12#	447.64	1,011.69	1,182,757.64
7	2012-13#	467.54	1,061.40	1,268,763.67
8	2013-14#	488.46	1,114.29	1,363,700.54
9	2014-15#	510.57	1,171.32	1,471,912.94

The United Nations International Labour Organization (ILO) released its 2017 World Employment and Social Outlook report stating that unemployment in India is projected to increase from 17.7 million last year to 17.8 million in 2017 and 18 million next year. In percentage terms, unemployment rate will remain at 3.4 per cent in 2017-18 .In recent times the government of India is encouraging setting up of medium and small scale enterprise for increases industrial production.

Towards this direction use of cobotics will immensely help because of its distinguishing features like low cost, ease of handling and collaboration with human. Introducing them in the shop floors will be advantageous as they serve as an intelligent tool for the workers. And they can marginally solve the problem of unemployment because they are the compromise between productivity and unemployment due to automation.

Table 5 : It gives a picture of the employment in the working enterprises of MSME (micro, small and medium enterprises)

Table 6 : It gives the statistics of their contribution to the total GDP of India.

Table 6: Share of MSME in GDP

Year	Gross Value of Output of MSME Manufacturing Sector (₹ in crore)	Share of MSME sector in total GDP (%)			Share of MSME Manufacturing output in total Manufacturing Output (%)
		Manufacturing Sector MSME	Services Sector MSME	Total	
2006-07	1198818	7.73	27.40	35.13	42.02
2007-08	1322777	7.81	27.60	35.41	41.98
2008-09	1375589	7.52	28.60	36.12	40.79
2009-10	1488352	7.45	28.60	36.05	39.63
2010-11	1653622	7.39	29.30	36.69	38.50
2011-12	1788584	7.27	30.70	37.97	37.47
2012-13	1809976	7.04	30.50	37.54	37.33

8. ACTIVE COBOTIC APPLICATIONS:

8.1 UNIVERSAL ROBOTS:

UR3: It's a compact table-top robot which weighs only 11 kg, but has a payload of 3 kg, 360-degree rotation on all wrist joints and infinite rotation on the end joint. The UR3 collaborative robot is an optimal assistant in assembly, polish, glue, and screw applications requiring uniform product quality. ESTIMATED COST: Rs.22,34,068

UR5 : It can automate repetitive and dangerous tasks with payloads of up to 5 kg with a working radius of up to 850mm. The UR5 is ideal to optimize low-weight collaborative processes, such as: picking, placing and testing. ESTIMATED COST : Rs.28,73,373

UR10: It can automate tasks up to 10 kg with a working radius up to 1300mm and with fast playback time and flexible development .The UR10 is ideal to optimize heavier-weight collaborative processes, such as: packaging, palletizing, assembly and pick and place . ESTIMATED COST:Rs. 36,06,423

8.2 ITROLLEY: RAIL-BASED, POWER-ASSIST COBOT:

The iTrolley cobot (manufactured by Stanley Assembly) is a commercially available product, and installed at Ford Motor Company's Advanced Manufacturing Technology Division. Passive overhead rail systems are very popular in automobile final assembly plants, as well as in many other applications in materials handling. A rail system may be converted into a cobot by the addition of CVT elements which are adjustable under computer control, and a sensor which is used to monitor the user's applied force. It allows the addition of a limited amount of power assist to help the user overcome the inherent friction of the rail system.

8.3 ILIFT: POWER ASSISTED LIFTER:

The Stanley iLift [Stanley] is a fully active power assisted lifting device. The operator controls the vertical position of the load via a vertical slider which is attached to the end effector. The power assistance is strictly one dimensional, however the system can also be used in conjunction withstandard rail systems of the iTrolley to obtain additional degrees of freedom. The two main models of iLift are capable of handling loads of 68kg and 226kg respectively at lift speeds of upto 1.5m/s and 0.7m/s.The iLift and iTrolley were developed initially by the Cobotics company, which was recently acquired by Stanley.

9. IMAGINING THE FUTURE

According to faulring the development of cobots with larger workspaces, powered actuators, and damping and stiffness schemes will provide numerous new capabilities to the implementation of cobot and haptic technologies.

Automobile Industries : Automotive designers could test the operation of a virtual parking brake or shifter, walk around a full-scale virtual car, or lean under the hood to see if they can reach where the oil filter or spark plugs have been placed. As the designer tests the parking brake's action, or removes the virtual oil filter, the objects on the end of the cobotic arm could be provided with the stiffness and friction characteristics being tested. Assembly workers will suffer less repetitive strain injuries as cobot guided material handling actions are made more ergonomic. Automotive components with large inertias could be constrained to a small subset of six degrees of freedom, allowing workers to easily perform secondary tasks such as wiring and fastener installation.

Hospitals: Surgeons could plan a surgery by analysing offline MRI data or real time X-ray or fluoroscopy data to determine boundaries that surgical instruments should not penetrate. If the surgeon's implement is fixed in a cobot, the cobot could keep the tool from penetrating vital organs while the surgeon still controls the allowed actions of the implement.

Much research is required to overcome the current limitations of the cobot technology in order to realize these predictions. In particular, in the context of *meat processing*, the following issues need addressing.

(1) A cobot with sufficient dexterity to handle, for example, a meat processing operation needs to be able to move in all six dimensions. Such higher degree-of-freedom cobot shave significantly smaller workspace compared to traditional industrial robots. Cobots with large workspace such as the Pallet Jack cobot have only three degrees-of-freedom.

(2) Typical cobots are unable to amplify a human's force. Cobots such as the Stanley rail based cobot can only provide limited assistance. The absence of power to move links relative to one another is the main reason for this as current cobots can only steer links relative to one another.

(3) Sensing ability of the current cobotic systems and the control strategies available for responding to the sensor measurements are very limited.

(4) Current generation of cobots are unlikely to provide a sufficient speed of response to maintain current productivity.

(5) Safety issues in the context where a common workspace is shared between a robot and a human may prevent the use of fast and active cobots for meat processing.

10.KEY RESEARCH GROUPS:

The activities of the key research groups in cobotics and related areas are briefly described below.

10.1 Laboratory for Intelligent Mechanical Systems (LIMS), Northwestern University:

This group's led by Professors Colgate and Peshkin coined the term cobotics and has been active in this area since 1996. The current research is focused on haptic devices,tele-operation and human interaction with passive robots, in particular for biomedical applications.

10.2 Department of Mechanical engineering and Division of Bioengineering, National University of Singapore:

This group is collaborating with the researchers at LIMS on cobotics. The focus is on the application of cobotics in wheelchair path and motion planning.

10.3 College of Mechanical and Electrical Engineering, Harbin Engineering University, China :

A research team at Harbin have developed a five-linkage serial cobot which uses two continuously variable transmissions connected in parallel mode. Design, and the trajectory planning and control of such robots is the research focus of this team. In addition to the groups that focus directly on cobotics, there is a very large research community in robotics and related areas.The research outcomes in this community should be useful in the red meat processing and cobotic systems.

NOTE: Currently the Leuven group is collaborating with Toyota to develop a human-robot collaborative system to install windscreens on cars.

10.4 The Fraunhofer Institute, Stuttgart:

It is an organization that is active in the area of robot assistants. The 2005 paper by Schraft describes a robotic assistant for assembly tasks, and also contains a useful conceptual overview of robotic assistants.

11.CONCLUSIONS:

Cobots are capable helping and serving the industry better by introducing automation without creating a fear of unemployment. This can also lead to increase in productivity in industries especially small to medium scale industries by tactfully introducing the technology to compensate the drawbacks of human labour without compromising on productivity.

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