Robotics - Past, Present and Future

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The earliest glimmer of robotics occurred in mythology. The dream of creating artificial humans paralleled the dream of creating wealth through alchemy to transform lead into gold. In Greek mythology we see sculptor Pygmalion fall in love with his statue of Galatea. Venus, the goddess of love, takes pity on Pygmalion and breathes life into the cold marble.

And, in the Middle Ages in middle Europe, folks believed in the Golem, a creature created out of mud and embedded with superhuman capabilities. Then in the 1400s and 1700s ingenious designers built robots out of cams, gears, springs and music box drums to emulate human activities such as piano playing and letter writing. We have all along wanted to believe that robots could be created though human cleverness and magic.

It would be human cleverness and not magic that eventually made robotics practical. As late as the 1939 World Fair in New York, Westinghouse created a robot exhibition featuring Electro and Sparky, a robot and his pet dog. They were hits but their technology was of the 1500s, cams, gears, and so forth.

Despite the wistful dreaming, a useful robot would not become possible until after World War II. Charlie Chaplin in his incisive film, *Modern Times*, had by 1936 foretold the need for robotics by demonstrating the enervating effect of modern manufacturing upon the human psyche. Yet, it was not to be until our technical tool kit included servo technology, digital logic and solid state electronics.

Victor Hugo wrote that there is no power on earth so strong as "an idea whose time has come." The idea was rattling around with Capek's 1922 play Rossum's Universal Robots and in the 1940s' stories of Asimov that set the rules for robot morality.

The Three Laws of Robotics

1. A robot must not harm a human being, nor through inaction allow one to come to harm.
2. A robot must always obey human beings, unless that is in conflict with the first law.
3. A robot must protect itself from harm, unless that is in conflict with the first or second laws.

Armed with aerospace technology of the moment and a seminal patent by one George C. Devol, my company Consolidated Controls Corporation undertook to build an industrial robot. By 1961, that Unimate® robot went to work in a General Motors plant. It operated a die cast machine, the arch typical hot and hazardous job that human workers might best be relieved of. Unimate 001 is now in the Smithsonian Museum after working the lifetime hours of a human laborer unto retirement.

Hurrying past the origins to the present we see an international industry now running at approximately six billion dollars per year. That industry was born of U.S. innovation but has prospered largely as the result of Japanese implementation. **Figure 1** is a broad but necessarily incomplete list of jobs performed by robots for the economic as well the social benefit of industry employers and employees.

I have said that a practical industrial robot awaited technology. Emergence of the available technology set the scene for Unimation Inc. We could build a hydraulic powered robot with record playback programming to attack those heavy duty chores that demanded husky male labor using both hands. It was the automotive industry that first saw the potential. The work was hard and operations ran two shifts. Robots earned their keep.

It was in 1967 that Japan flexed its muscle. My privilege was to push the embryo industry in Tokyo. There was no time wasted, JIRA was born with 47 members! Okay, the innovation came from the USA. But Japan became the producers. By the 1990s, Japan's robot manufacturers were dominating the industrial robot industry. Japanese manufacturers had improved reliability from an initial 400 hour MTBF to an MTBF of 15,000 hours. After proving the technology in Japanese industry, Japan spread its wings to offer conservative, reliable industrial robots worldwide.

Here we are today with a six billion dollar industry dominated by Japan. Robotics, justified originally only by cost saving, can now claim advantages of quality, throughput and human safety.

What next?

Now it is time to look forward. The industrial robot scene is stable. Robots have become commodities. There are green ones, orange ones, blue ones all with similar specifications. Ho hum! Meanwhile the technology pertinent to robotics has outstripped industrial robotics. When robots can truly see, feel and understand spoken commands they can aspire to tasks in the unstructured world in which we lead our daily lives. A spectrum of such applications were proposed in my 1989 book, Robotics in Service. These applications are listed in the next two slides (**Figure 2**). A culmination comes in robotics devoted to personal service. That would be great fun for most of us and a great boon for those of us who are elderly, frail and unable to live independently.

In **Figure 3** we see a compendium of capabilities, largely sensory, that will enable robots to cope effectively with the jobs listed in Figure 2.

A "Golden Age" approaches for robotics. It will be driven by the available technology applied to the needs of an aging citizenry. Throughout the industrialized world the fastest growing population is the aged, still cognitive, but physically handicapped. Robots will serve these folks in a personal and competent fashion that can no longer be expected of their progeny. Senior citizens, living independently with robot caregivers, will enjoy help in daily living at a much lower cost than could be offered by conventional nursing home service.

As a cause celebré I reach out internationally for sponsors of the final development of a robot caregiver. How wonderful for commercial interests to enjoy remarkable profitability while adding quality to the twilight years of our seniors. Following is a short list of likely tasks for a robotic caregiver - fetch and carry, meal preparation, clean house, monitor vital signs, assist ambulation, manage the environment, communicate by voice, take emergency action - and in **Figure 4** we see jut one kindly act, "offering an arm." What excitement to be facing such a fine challenge at the turn of the century!

CURRENT APPLICATIONS

Die Casting	Machine Loading
Spot Welding	Stamping
Arc Welding	Plastic Molding
Glass Handling	Investment Casting
Heat Treatment	Conveyor Transfer
Forging	Palletizing
Paint Spraying	Inspection
Fettling	Order Picking
Lab Automation	Batch Assembly

Figure 1

SERVICE ROBOT APPLICATIONS

Hospital Porter	Farming
Commercial Cleaning	Gas Station Attendant
Guard Service	Hotel Bell Boy
Nuclear Power Maintenance	Space Vehicle Assembly
Underwater Maintenance	Military Combat
Parapharmacist	Companion for Infirm
Parasurgeon	or Handicapped

Figure 2

Robotics Toolchest

Electronics
- Low-cost, high-speed microprocessors
- Vast memories, negligible cost

Servos
- DC
- AC
- Stepper
- Hydraulic

Controllers
- Point-to-point
- Continuous path
- Sensor-driven

Application Software
- VAL
- KAREL
- RCCL
- and others

Position and Motion Sensors
- Encoders
- Resolvers
- Compasses
- Passive beacons
- Active beacons
- Ceiling vision
- Inertial(Gyro)
- Clinometer
- GPS

Range Scanning
- Ultrasound
- Light triangulation
- LIDAR
- Optical flow
- Capacitive
- Inductive

Vision
- Structured light
- Stereo
- Scene analysis
- Template matching
- Colorimeter
- Bar code readers

Tactility
- Wrist force sensing
- Torque sensing
- Fingertip arrays
- Limit switches
- Contact bumpers

Voice Communication
- Synthesis
- Recognition

Artificial Intelligence
- Expert systems
- Sensory fusion
- Fuzzy logic
- Semantic networks

Figure 3

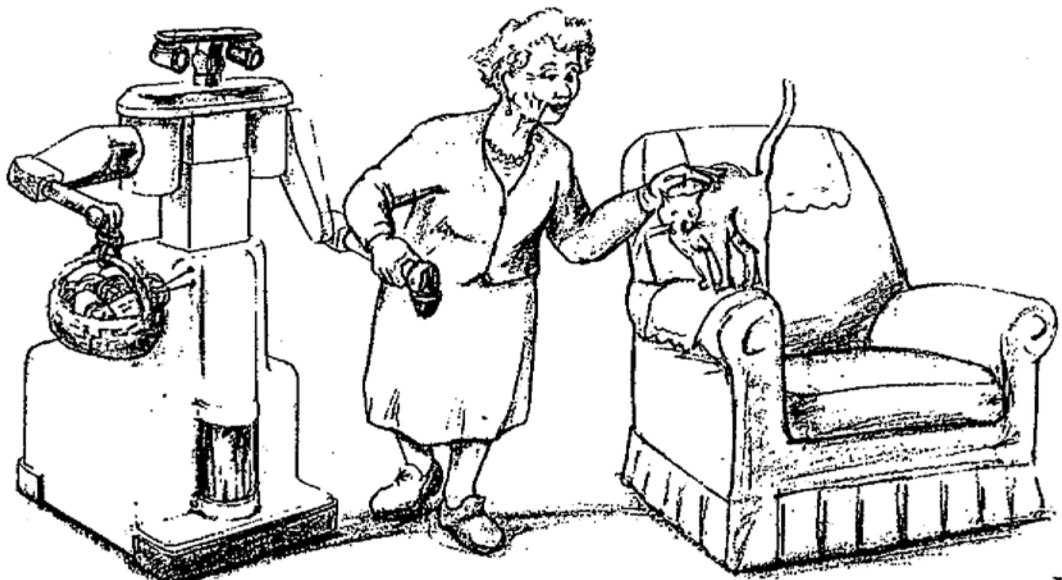

Figure 4