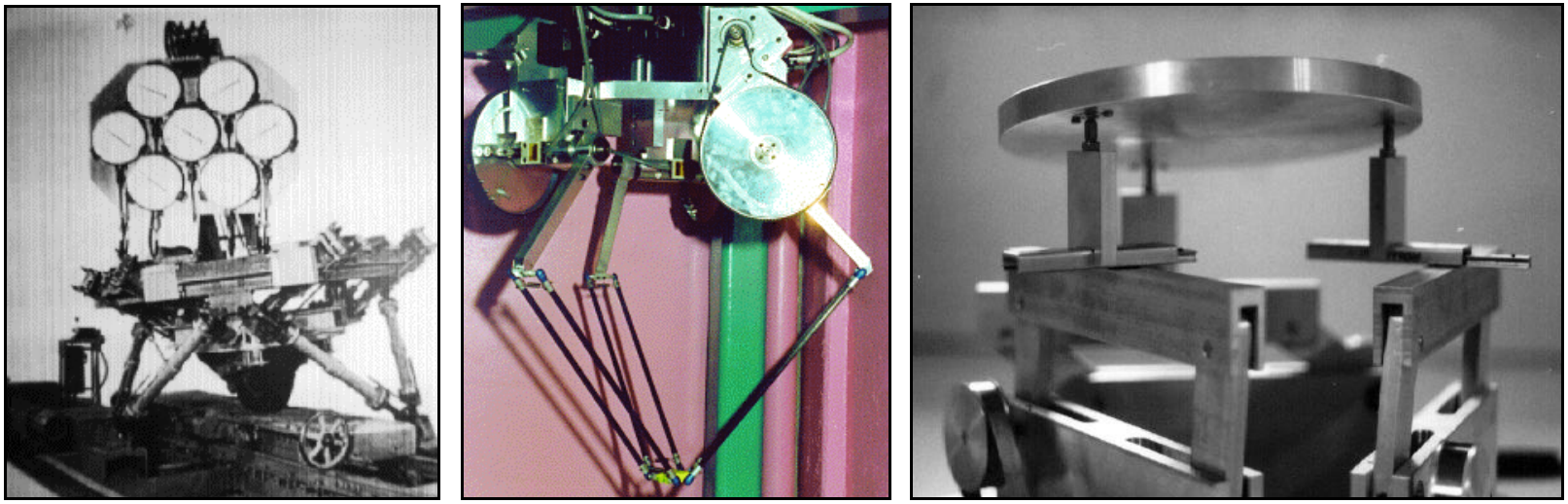
parallel architectures,
in order to obtain larger payload, greater stiffness and accuracy

Several new designs have been conceived and in the last decade lot of prototypes have been built, but only few of them went out from laboratories and has already success in industrial applications.



a) b) c)

Fig. 9: Parallel Manipulators: a) Stewart-Gough Platform in 1965; b) Delta robot built in 1988; c) Cassino Parallel Manipulator built in 1997. (Photos are taken from web pages)

CaPaMan has been conceive in Cassino as a result of the emerging friendly-oriented strategy in designing and operating robotic systems with simple mechanical designs (see the four-bar linkage in the legs) and easy operation programming (because of the kinematic properties of the kinematic architecture).

Hybrid architectures

are the new solutions that addressed great attention of the investigators at the end of 90s.

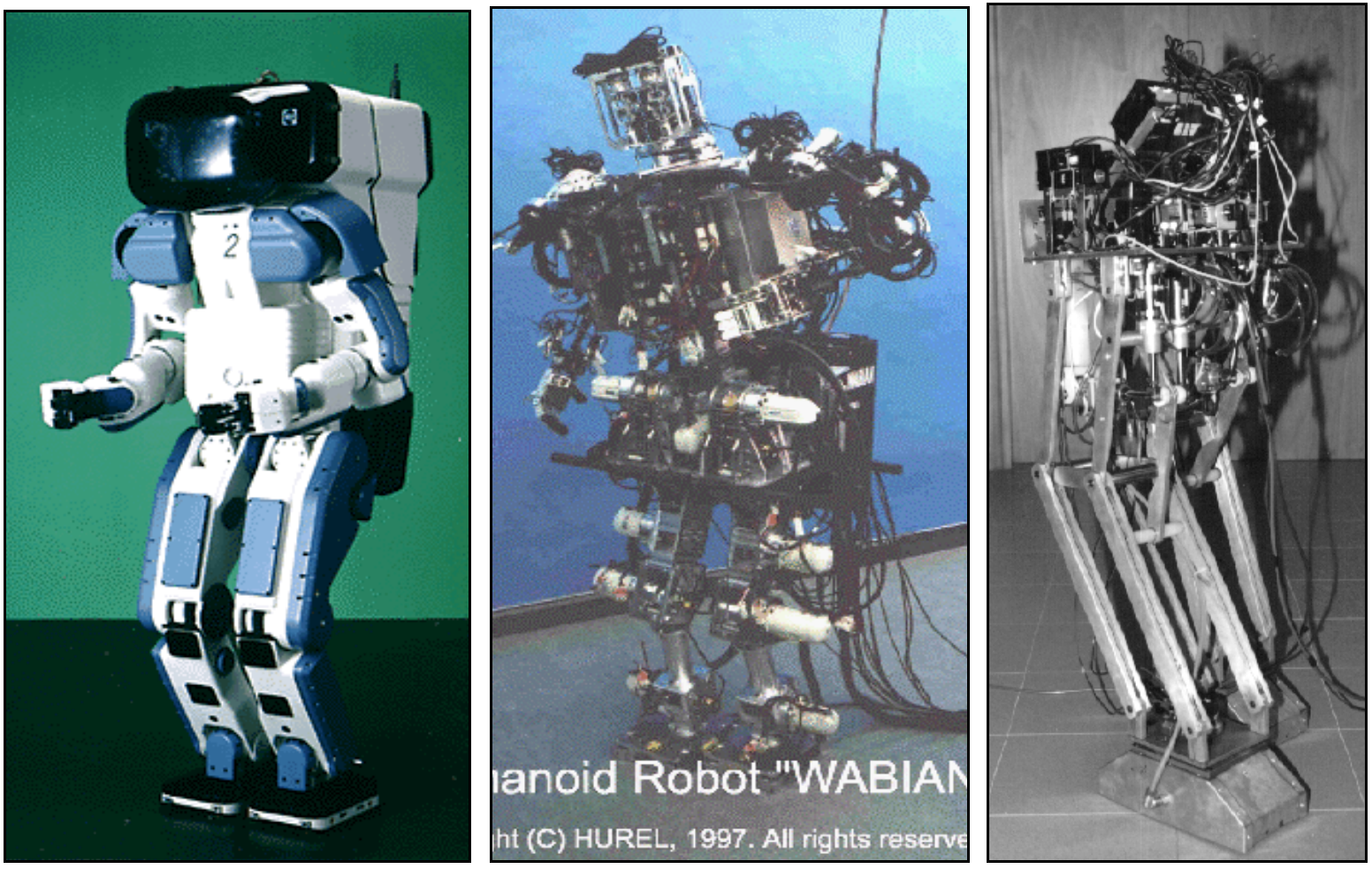
They consist of a combination of serial and parallel kinematic chains in several way in order to obtain the advantages and limit the drawbacks of both the architectures.

Mobile robots

They were developed mainly as wheeled systems, but since the beginning of 80s walking machines were studied, designed, and built with mechanical designs that copied or emulated deambulation structures of animals, including insects.

in the 90s there several attempts to assembly arms, walking machines, hands, and other robotic structures in a unique system in order to obtain the utopic solution of the complete robot. Thus, not only humanoid robots have been experienced but also other assemblages, recalling or not structures in nature.

A specific field has been identified as related with **Humanoid robots**.



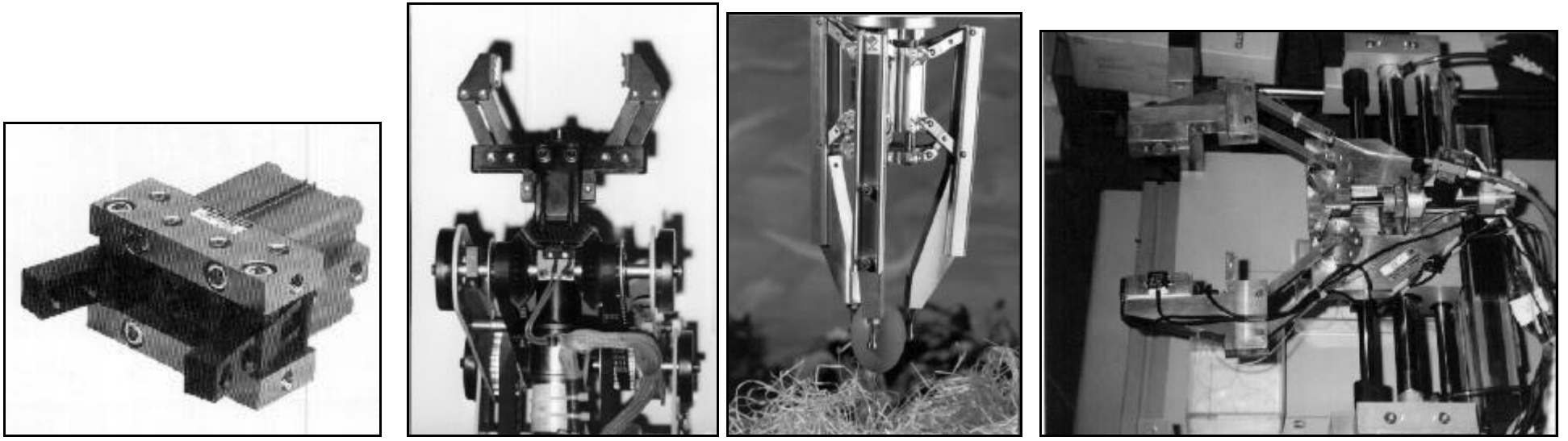
a) b) c)

Fig. 10: Walking robots: a) Honda robot built in 1993; b) Waseda robot version of 1997; c) EP-WAR built in 1996. (Photos are taken from web pages)

end-effectors

were and are still designed and used for grasping specific objects and they are widely used in industrial applications as economic solutions that simplify the mechanical structures and execution complexity of a more universal hand.

Their optimum design and successful operation is based of an in-depth study of the mechanics of grasp, that is still subject of investigation.



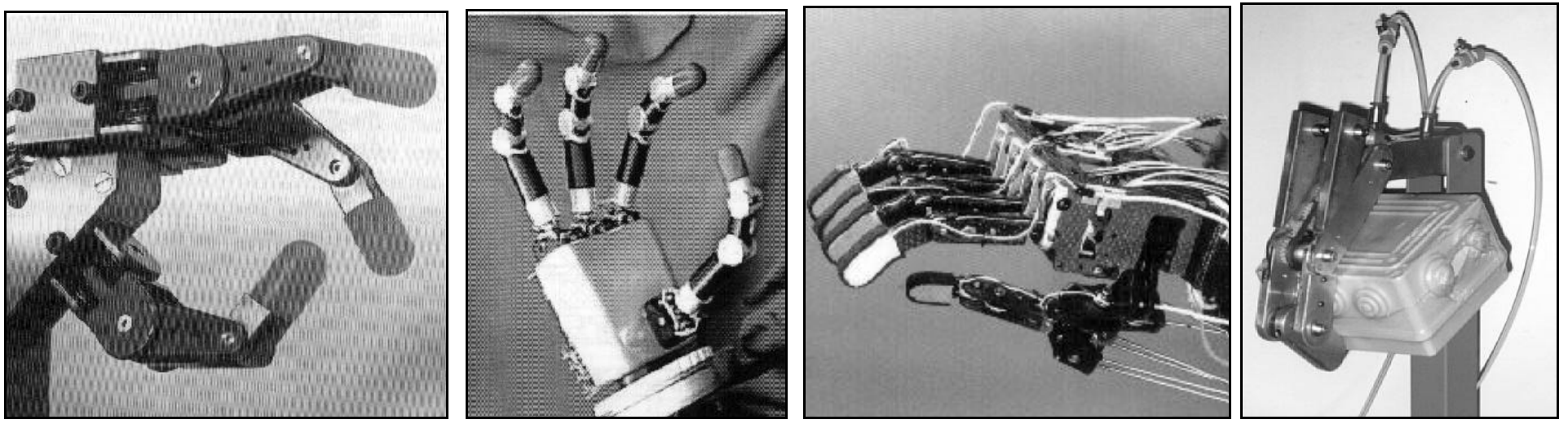
a) b) c) d)

Fig. 17: Robotic grippers: a) a two-finger industrial gripper, [24]; b) a two-finger gripper for robot applications, [25]; c) a three-finger gripper, [26]; d) a sensored two-finger gripper for test-bed applications in the Laboratory of Robotics and Mechatronics in Cassino.

Artificial hands

addressed attention of the researchers since the beginning of 80s with the aim to develop designs, which are similar or even equal to the human hand.

However, the complexity and versatility of human hands has not yet been replicated but several reduced versions have been successfully obtained.



a) b) c) d)

Fig. 18: Robotic hands: a) Salisbury hand built at Stanford University in U.S.A. in1982, [1]; b) DRL hand built at Munich University in Germany in 1997, [27]; c) WAM-8R hand built at Waseda University Japan in 1985, [28]; a low-cost easy operated articulated finger prototype built at Laboratory of Robotics and Mechatronics in Cassino in 1999.

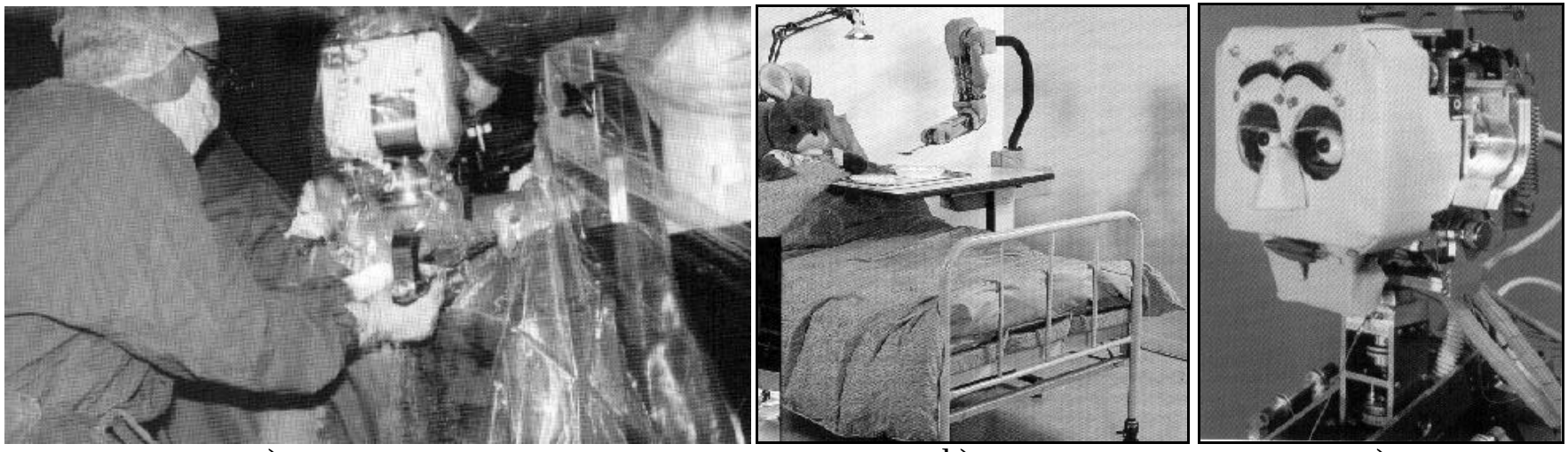
- The continuos evolution of Electronics and Sensors has given continuously stimulus for new research activity that obtained and continuously obtains enhancements in new and old prototypes.
- the field of robotic hands has been grown and still evolves rapidly because of improvement and miniaturization of the involved technologies.

Service robots

are robots that are applied for in-door tasks devoted to help in human activity like house or hospital keeping and cleaning, even helping handicapped men.

But the field is further very promising when one includes that

co-operations of many robots can perform very complex tasks.



a) b) c)

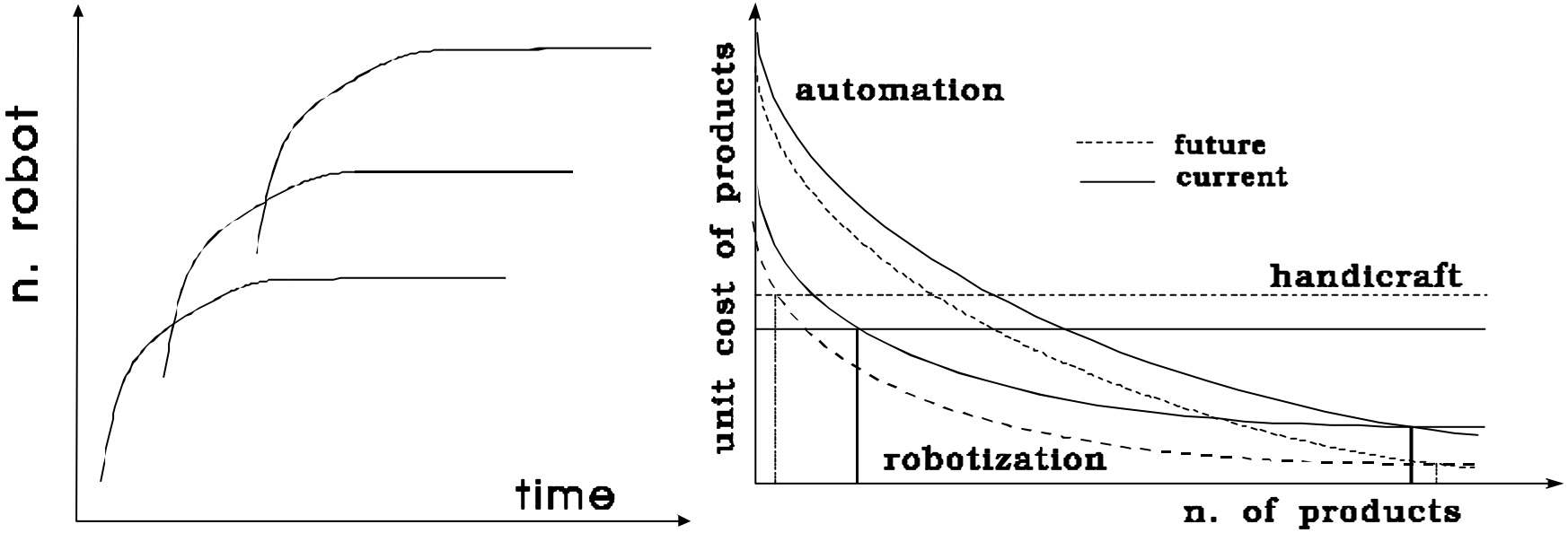
Fig. 19: Examples of service robots in medical fiels: a) in surgery applications, [29]; b) in hospital assistance, [30]; c) a Kansei prototype, [28].

FUTURE CHALLENGES FOR ROBOTS

Many roboticists are sure of an optimistic future on developments of Robotics, both in term of theoretical enhancements and practical applications.

However, critical issues can be advised as challenges in the future activity in Robotics regarding:

- low-cost system design;
- easy-operated systems;
- innovative solutions for new field of applications.



a) b)

Fig. 11: Motivations for optimistic future of Robotics :
a) trend for new applications; b) variation of cost manufacturing production.

A fundamental challenge consists of how to execute tasks by robotic systems with easy operation.

Great emphasis and attention is already addressed to innovative solutions for future applications

Innovation

is expected not only in term of new robotic systems but also as associated to low-cost and easy operated systems that can be dedicated to friendly use of robots.

In particular, regarding short term evolution, new robotic systems will be developed for:

- **service robots**
- **space and submarine exploration and work**
- **humanoid robots**
- **robots for medical applications**
- **robot for Agriculture**
- **...**

Service robots

will be developed more and more with specific designs but mostly for a friendly use and co-operation with humans, even not trained for using robots.

- This means that great efforts should be spent to make the robot acceptable as a friend or company in many service applications, by evolving even in term of shape and esthetic appearance.

Dangerous applications

like space and submarine exploration, even work and colonization, will require more and more robots, but with robust design and very advanced features to survive in hard environment for long duration with very reliable operation capability.

Specific attention has been addressed recently to **humanoid robots** and great results are expected to achieve the reality of the utopia of having a robot that can substitute a man in a work activity without any supervision.

The use of **robots in medical fields**

Many important achievements are expected mostly to help the surgery, assistance, rehabilitation and other activity of any kind of patients.

The hard task, beside the complex technical contents, consists in stimulating a successful collaboration of two worlds that are some antithetic: the Medicine and robot Engineering.

- **Only ten years ago this cooperation were considered impossible!**

Indeed, many other collaborations that are not possible today will be asked to roboticists.

Another very important challenge can be considered

the use of robots in Agriculture.

In the 80s there first attempts of robotic harvesting of horticultural products and fruits from trees, mainly citrus.

Innovative solutions are expected mainly for

spreading robots more and more

by simplifying the execution and making cheaper the robotic systems.

This trend is already a current issue for Robotics but in the future it could become critical for the success and even survive of robots.

Thus a challenge problem can be considered

- **how to obtain sophisticated advance solutions**
- **required by the technical needs**
- **but with no great operation complexity.**

Finally, the most important **challenge for roboticists**

in the future can be considered to have capability to attach problems and develop solutions in shorter and shorter time in new and new fields of application that will be defined suddenly and suddenly in the future, probably without the chance, that we have today, to study and practice with prototypes in research centers.

CONCLUSIONS

- a knowledge of historical background and motivation of innovations over time can be of great help for the future success of Robotics,

when the reader understands that robots are the natural evolution of automatic systems and represent the necessary means for the society of the future

In particular, the paper
shows emblematic examples, which give illustration of the few stressed concepts and historical aspects:

- the robotic system is an idea that comes from Antiquity, and it was existent all around the world at different technical levels;
- automatas and early robots were designed, built, and used with motivations and applications that are sometimes similar to those of today;
- modern Robotics is a high-speed evolving field;
- and the future success of robots depends on popular acceptance of them that will be based on human friendly designs and operations.
- ……