<u>ARTIFICIAL INTELLIGENCE AND ROBOTICS</u>

Author: Ramnik

Research Scholar,

Faculty of Computer Science,

Dr. Babasaheb Ambedkar Technological, University, Lonere.

<u>ABSTRACT</u>

Artificial Intelligence (AI) is ostensibly the most astonishing field in mechanical technology. It's positively the most dubious: Everybody concurs that a robot can work in a sequential construction system, however there's no agreement on whether a robot can at any point be astute. Robots are considered as counterfeit specialists that acknowledge assignments in a programmed way. In spite of the fact that they might be made uniquely out of programming (called bots), robots are related with actual presence, regardless of whether that is humanoid/human (Nomura et al., 2012) like Honda's ASIMO or not, e.g., modern mechanical arms, nano-robots, self-driving vehicles (Rödel et al., 2014). For the most part, robots portray qualities like self-rule, self-learning, actual presence and transformation of its practices and activities to its current circumstance (Nevejans, 2016). This work relates the regions falsely astute robots and society and their interaction. A future harmonious relationship with robots that may prompt a civilizational change with broad impacts is the main impetus behind this examination.

<u>INTRODUCTION</u>

Artificial Intelligence and Robotics have a typical root and a (moderately) long history of cooperation and logical conversation. The introduction of Artificial Intelligence and Robotics happens in a similar period ('50), and at first there was no reasonable differentiation between the two disciplines. The explanation is that the thought of "shrewd machine" normally prompts robots and Robotics. One may contend that few out of every odd machine is a robot, and positively Artificial Intelligence is concerned additionally with virtual specialists (for example specialists that are not typified in an actual machine). Then again, large numbers of the specialized issues and arrangements that are required to plan robots are not managed by Artificial Intelligence research. An unmistakable partition between the fields can be found in the '70, when Robotics turns out to be more centered on mechanical mechanization, while

Artificial Intelligence utilizes robots to exhibit that machines can act additionally in ordinary conditions.

Afterward, the troubles experienced in the plan of mechanical frameworks fit to act in unconstrained conditions drove AI specialists to excuse Robotics as a favored test bed for Artificial Intelligence. Then again, the examination in Robotics prompted the improvement of an ever increasing number of refined mechanical robots. This situation changed during the '90s, when robots started to populate again AI research facilities and Robotics explicitly tended to likewise less controlled conditions. Specifically, robot competitions1 began: in fact they assumed a significant part in restoring a severe connection among AI and Robotics that is these days perhaps the most encouraging advancements of examination both in the public setting and at the European level.

Summing up, the halfway point between the work in Artificial Intelligent and Robotics is positively undeniably challenging to set up; notwithstanding, the issues to be addressed to assemble savvy robots are obviously recognized by the exploration local area, and the improvement of robots is again seen as a prototypical instance of AI framework. Following the title of the paper we will allude to this collection of exploration as AI Robotics. We finish up this concise presentation with a disclaimer: the perspectives introduced in the paper are those of AI research, those utilization robots as a favored model of canny specialist and there is no endeavor to give a complete review. In the new years, Robotics scientists have additionally handled a portion of the issues that are managed in the current paper, yet the perspective on Robotics research towards Artificial Intelligence may not be as expected reflected in the paper.

The paper is coordinated as follows. In the following area we address the major logical issues in the field. Then, at that point we take a gander at the associations and associations with different subjects tended to in this assortment, and with different disciplines. A while later, we present some application situations that have been created by the exploration in Italy.

RESEARCH ISSUES

In this section we analyses the recent work which can becharacterized as AI Robotics, by arranging it into the two basic issues in robot design: Action and Perception.

Action

While there is these days an overall concurrence on the essential design of the independent specialist/robot, the topic of how this construction can be carried out has been dependent upon a long discussion is as yet being scrutinized. Specialists and, explicitly, robots, typically present different sorts of detecting and acting gadgets. The progression of information from the sensors to the actuators is handled by a few distinct modules and the portrayal of the connection among these modules characterizes the specialist's engineering.

The first, absolutely deliberative, structures see the robot as a specialist inserting an undeniable level portrayal of the climate and of the activities that it can perform. Perceptual information are deciphered for making a model of the world, an organizer produces the activities to be performed, and the execution module deals with executing these plans. By and by a sense-plan-act cycle is more than once executed. The issue is that building an undeniable level world model and producing an arrangement are tedious exercises and subsequently these frameworks have demonstrated to be lacking for specialists implanted in unique universes. Receptive structures center on the essential functionalities of the robot, like route or sensor understanding, and propose an immediate association among upgrades and reaction. Creeks' subsumption engineering is made by levels out of ability containing a class of undertaking focused practices. Each level is responsible for achieving a particular assignment (like deterrent aversion, meandering, and so on) and the perceptual information are deciphered distinctly for that particular errand. Receptive structures, while reasonably tending to the elements of the climate, don't by and large permit the originator to think about broad parts of discernment (not identified with a particular conduct), and to recognize complex circumstances. Truth be told, the utilization of a representative undeniable level language is preposterous, since it would essentially require building a world model, and hence thinking is generally arranged into the designs of the executing program.

The absence of previsions about as far as possible these frameworks as far as productivity and objective accomplishment. The above contemplations prompted a recharged exertion to consolidate a rationale based perspective on the robot as a savvy specialist, with its receptive functionalities. To this end another exploration field is creating somewhat recently: Cognitive Robotics. The name was first presented by the examination bunch at the University of

Toronto drove by Ray Reiter. The latest perspective on intellectual robots, that has been acknowledged, for instance in the EU structure, unquestionably keeps the first objective of implanting a thinking specialist into a genuine robot, yet additionally takes a more broad point of view, by taking a gander at the discernment/activity cycle from a more extensive perspective, in bio-motivated frameworks, just as in the work on acknowledgment and age of enthusiastic practices (see next segment). Intellectual Robotics targets planning and acknowledging genuine specialists (specifically portable robots) that can achieve complex undertakings in genuine and henceforth powerful, unusual and deficiently known conditions, without human help.

Psychological robots can be controlled at a significant level, by giving them a depiction of the world and communicating the assignments to be acted as objectives to be accomplished. The describing highlight of an intellectual robot is the presence of psychological capacities for thinking about the data detected from the climate and about the activities it can perform. The plan and acknowledgment of psychological robots has been tended to according to alternate points of view that can be ordered into two gatherings: activity hypotheses and framework models.

Activity hypotheses various speculations of activities have been created to address the specialist's information. They are portrayed by the expressive force that is the capacity of addressing complex circumstances, by the deductive administrations permitted, and by the execution of programmed thinking techniques. A few formalisms have been explored beginning from Reiter's Situation Calculus: A-Languages, Dynamic Logics, Fluent and Event Calculi. The proposed formalisms address a few parts of activity portrayal including detecting, tirelessness, non-determinism, and simultaneousness. In addition, they have been additionally reached out with probabistic portrayals, portrayals of time and so on In any case, a significant part of the work completed on activity hypotheses has been separated from applications on genuine robots, for certain outstanding special cases. A more mainstream way to deal with activity portrayal on robots depends on dynamic procedures, which amplify the utility of the activities chose by the robot, contingent upon the functional setting. Notwithstanding, this methodology doesn't give an unequivocal portrayal of the properties that describe the powerful framework, while zeroing in on the activity choice system. Models

There are numerous highlights that are viewed as significant in the plan of specialists' designs and every proposition depicts an answer that accommodates a portion of these highlights. Ways to deal with models that attempt to join representative and responsive thinking are introduced for instance in as purported Hybrid Architectures. We can generally depict layered mixture engineering of a specialist with two levels: the deliberative level, wherein an undeniable level condition of the specialist is kept up with and choices on which activities are to be performed are taken, and the usable level, where conditions on the world are checked and activities are really executed. The typified knowledge approach sums up Brooks' thoughts. The robot is a genuine actual specialist firmly communicating with the climate and the robot conduct is created not by the robot regulator alone, but rather it arises through the cooperation between the robot with its body and the climate. Different commitments to the acknowledgment of robot designs come from transformative figuring, where developmental advanced mechanics is an exploration field targeting creating robots through transformative cycles enlivened by organic frameworks. For instance, neuro-fluffy frameworks have been effectively utilized in the plan of robot models. Regularly, the work on models is created with regards to robot programming conditions, including impromptu particular control dialects. The majority of this work is more worried about designing perspectives and won't be tended to here.

Perception

Robot discernment is a noticeable exploration field in AI and Robotics. Current automated frameworks have been restricted by visual discernment frameworks. Truth be told, robots need to utilize different sorts of sensors, for example, laser range locater, sonar, etc. to sidestep the troubles of vision in powerful and unstructured conditions.

A mechanical specialist acting in reality needs to manage rich and unstructured conditions that are populated by moving and cooperating objects, by different specialists (robots or individuals, etc. To suitably move and act, a robot should have the option to comprehend the view of the climate. Understanding, according to an AI viewpoint, includes the age of a significant level, decisive portrayal of the apparent world. Growing such a depiction requires both base up, information driven cycles that partner emblematic information portrayal structures with the information emerging from a dream framework, and hierarchical cycles in

which undeniable level, representative data is utilized to drive and further refine the translation of the scene.

To achieve its errands, a robot should be invested with particular thinking abilities, to decipher, group, follow and expect the conduct of the encompassing articles and specialists. Such capacities require rich internal portrayals of the climate solidly moored to the info signals coming from the sensors. All in all, the significance of the images of the robot thinking framework should be moored in sensorimotor instruments. On the one side, the robot vision local area moved toward the issue of the portrayal of scenes for the most part as far as 2D/3D reproduction of shapes and of recuperation of their movement boundaries, conceivably within the sight of commotion and impediments, to control the movement of the robot. This methodology is known as visual serving of robot framework. On the opposite side, the AI people group created rich and expressive formalisms for picture translation and for portrayal of cycles, occasions, and activities and, as a rule, of dynamic circumstances, as referenced in the past segment. Nonetheless, the examination on robot vision and on AI information portrayal developed independently, and focused on various types of issues. From one viewpoint, the robot vision analysts certainly expected that the issue of visual portrayal closes with the 2D/3D recreation of moving scenes and of their movement boundaries. Then again, the AI people group ordinarily didn't deal with the issue of securing the portrayals on the information coming from sensors.

Beginning from the original paper of Reiter and Mackworth, some proposition has been made in this exploration field, a couple of them momentarily depicted underneath. The fundamental strides toward a viable psychological vision framework for dynamic scene understanding have been as of late examined by embracing a fluffy metric transient Horn rationale to give a transitional formalism that addresses schematic and launched information about powerful scenes. This theoretical formalism intervenes between the spatiotemporal mathematical depictions extricated by camcorders and the significant level framework for the age of normal language text.

A connected framework depends on three degrees of portrayals: the sub theoretical, the calculated and the emblematic level. Specifically, the principle supposition that will be that a middle portrayal level is absent between the two classes of portrayals referenced previously.

To fill this hole, the thought of calculated space is received, a portrayal where data is described as far as a measurement space. A reasonable space goes about as a middle portrayal between sub calculated (i.e., not yet theoretically classified) data, and emblematically coordinated information. Some fundamental natives (Find, Track, and Reacquire) that characterize the mooring of images in tactile information as an issue essentially and autonomous of a particular execution have been proposed and examined.

To characterize a more broad intelligent record of robot insight connecting tangible information to significant level portrayal, as of late an abductive hypothesis of discernment has been proposed. In this hypothesis, the undertaking of robot insight is to discover and clarification of tangible information as indicated by a foundation hypothesis depicting the robot communications with the climate. Association with other AI Þelds As previously referenced, the exploration on AI Robotics converges various subfields of AI. Without a doubt, the automated specialist can be viewed as a primary objective for the fabulous objective of Artificial Intelligence, and accordingly for every one of the parts of AI to some degree identified with Robotics. Underneath, we address the fundamental associations with the other AI research subjects remembered for this assortment.

AI approaches are being applied to numerous issues emerging in the plan of robots. As per the design received above, both activity and discernment can be upheld by learning draws near. Additionally, a few methodologies that incorporate a preparation step are sought after going from AI ways to deal with hereditary programming, and neural organizations. From the angle of activity, learning approaches can be utilized for the essential activity abilities, explicitly velocity, yet in addition learning agreeable practices, variation to the climate, and learning adversaries' conduct, among others.

Clearly, the learning interaction should confront the difficulties of the trials with genuine robots. By the by, in a few trial settings (for example RoboCup), learning and transformation of the essential expertise, like strolling, vision alignment, have demonstrated to be considerably more powerful than boundary tuning by hand. Edutainment Toy robots are exceptionally encouraging to be utilized both for research purposes and for schooling, in view of low expenses and high fascination for understudies. Despite the fact that, right now, the accessible instructive packs appear to give too restricted abilities, toy robots are absolutely a

fascinating business market. Thus, the plan of shrewd toy robots is an intriguing chance for AI analysts. The involvement in Aibo robots shows this potential: they have been effectively utilized by much examinationbunches on the planet not just in the RoboCup contests (Four-Legged League), yet additionally for exhibiting other AI and Robotics research issues.

Multi specialist frameworks a multi-robot framework (MRS) can be considered as a multi-specialist framework (MAS), however the procedures for accomplishing coordination and participation in MAS are regularly not appropriate to manage the vulnerability and model inadequacy that are normal of Robotics. Various robots may accomplish more powerful and more viable conduct by achieving composed undertakings that are unrealistic for single robots. Gatherings of homogeneous and heterogeneous robots have an extraordinary potential for application in complex areas that may require the savvy utilize and converge of assorted capacities. The plan, execution, and assessment of robots coordinated as groups represent an assortment of logical and specialized difficulties.

Natural Language Processing- it is a conspicuous prerequisite of home and administration mechanical technology the capacity to communicate with individuals in normal language; along these lines, regular language handling procedures track down an intriguing application space on robots (see for instance the RoboCare project beneath). Rationales for AI and Automated Reasoning The association with the Logics for AI and Automated Reasoning are vital to the work on Cognitive Robotics; however we don't further grow it here, as it is examined in the past segment.

Transformative Computation and Genetic Programming Evolutionary Robotics is another methodology that views at robots as self-governing fake creatures that foster their own abilities in close connection with the climate without human mediation. Developmental mechanical technology in this way applies procedures coming from transformative calculation.

Association with different disciplines Robotics is a multidisciplinary field: to make a functional robot, a few commitments from numerous disciplines are required: physical science, electrical designing, electronic designing, mechanical designing, software engineering, AI, etc. It is subsequently troublesome likewise to have a typical foundation of

terms, documentations and approaches. In this sense, the endeavors to characterize a typical metaphysics of terms for a mechanical technology science are critical. Specifically, AI Robotics communicates with a few examination disciplines outside AI.

Modern Robotics Many contact focuses might be found between AI, Robotics and Industrial Robotics. In early days there were not satisfactory and cut differentiations between the two fields, as of now referenced. Today, research in Industrial Robotics is situated towards the protected and smart control of mechanical controllers and in the field of administration advanced mechanics. The procedures in Industrial Robotics are grounded in Automatic Control Theory. The connection between the robot and the climate is by and large demonstrated through a few sorts of criticism frameworks. Additionally, systems are normally founded on mathematical strategies and advancement hypothesis. PC Vision Robot Vision is explicit concerning PC vision, since Robot Vision is characteristically dynamic, as in the robot may effectively discover its data sources and it can likewise arrive at the best view position to boost the visual data.

Besides, Robot Vision should be acted continuously, on the grounds that the robot should quickly respond to visual upgrades. As a rule, the robot can't measure for quite a while a similar picture on the grounds that the ecological conditions may shift, so the robot needs to manage surmised, however in the nick of time data. A few exploration points and discussions in this field have solid relationships with AI and Robotics, for instance, if a Computer Vision framework might be founded on inward portrayal of the climate or it ought to be simply responsive.

Mechatronics- it includes skills from electrical designing, electronic designing, and mechanical designing. These capabilities are completely identified with AI and Robotics: the examination field of electrical designing concerns engines and actuators, while electronic designing principally concerns sheets for robot control, for information securing and overall for the equipment that makes the robot functional. Mechanical designing worries obviously the mechanical contraption of the actual robot. Starting here of view, Mechatronics, AI and Robotics have tight relations: Mechatronics chiefly centers around the robot equipment at all levels, while AI and Robotics deal with the product that makes the robot employable and independent.

Inserted Systems the AI programming engineering of a robot is normally installed into the actual contraption of the robot. Hence, the robot programming framework needs to work progressively to ensure that the robot accurately adapts to the evolving climate; it should be safeguard with smooth corruption to guarantee that the robot may work additionally in the event of harms; the equipment arrangement of the robot should be low force intended to upgrade the batteries, etc. Starting here of view, a few of the common difficulties of inserted frameworks are likewise difficulties for mechanical technology frameworks.

Human Robot Interface The field of Human Robot Interface (HRI) is identified with the connection modalities between the client and the robot. This field might be partitioned into two subfields: the intellectual HRI (cHRI) and the actual HRI (pHRI). Intellectual HRI dissects the progression of data between the client and the robot and it principally centers on cooperation modalities, which may length from printed interfaces to voice and signals. The interface might be pretty much savvy as in the robot might be obliged by a fixed arrangement of orders or it might decipher a string written in normal language or a grouping of signals performed by the administrator. The interface may likewise be versatile as in the robot may adjust to the administrator through a reasonable preparing stage. Actual HRI rather concerns the plan of characteristically safe robots. The primary thought is to mediate consistent components among engines and moving pieces of the robot to forestall harms in the event of effect, and without execution misfortune. Subsequently, cHRI research is firmly identified with the examination of AI and Robotics, while pHRI research is more connected with research in Industrial Robotics.

In this segment, we report on a couple of use situations, where the examination on Artificial Intelligence and Robotics has been created in Italy.

Robotic Soccer

RoboCup began its action around ten years prior by taking soccer matches (football for Europeans), as a logical proving ground for the exploration in AI and Robotics. Italian analysts gave a critical commitment to RoboCup throughout the long term, both at the association level and as far as taking part groups. RoboCup 2003 was held in Padova, and it

pulled in excess of 1,000 members from everywhere the world. Underneath we center on the associations, where the Italian investment has been more pertinent.

The Middle-Size class is played inside a 5x9 meters field by 4 wheeled robots for every group and the body of the robot should be inside a chamber of 50 cm distance across and 80 cm tallness. All detecting gadgets should be installed the robots, specifically worldwide vision just as other outside detecting gadgets are not accessible. The Italian interest in RoboCup was helped by the production of a public group, called ART (Azzurra Robot Team), shaped by a few colleges and the Consorzio Padova Ricerche. Workmanship acquired the second spot in 1999 and therefore it was parted into a few nearby groups: Golem, Artisti Veneti and Milan RoboCup group.

The Four Legged Robot alliance is played in 4x6 meters field by 4 four-legged Aibo robots. The Aibo have on board a shading camera and their mechanical construction gives 18 levels of opportunity. The accessibility of a standard stage has essentially added to the logical assessment of the arrangements proposed. The SPQR group partook in the opposition since 2000 acquiring the fourth spot and getting to the quarter finals a few times.

As of late, a Humanoid Robot association began to move toward a definitive objective of RoboCup to assemble a humanoid group to play with people. Humanoid Robotics is as of now one of the fundamental difficulties for some scientists, for the most part zeroing in on mechanics and headway. Politecnico of Torino fostered the humanoid robot Isaac that has partaken to RoboCup Humanoid League since 2003. IASLab of University of Padova later joined the Humanoid League, with a completely self-ruling humanoid robot that utilizes an omnidirectional visor. It merits underscoring that the ART public model prompted logical and specialized achievement: ART showed the capacity to acknowledge serious automated football players, yet chief the capacity to mix in a solitary public group approaches and execution procedures independently created by the examination gatherings. In this regard, the work done on the issue of coordination, prompting the meaning of correspondence and coordination conventions utilized by the ART players has been both extremely testing and exceptionally fruitful. At last, cooperation/rivalry accomplished in the task has been crucial for the end-product, since it took into account an undertaking improvement with a tight collaboration and trade of results, contrasted with traditional examination projects.

Rescue Robotics

Other than soccer, RoboCup advances different associations, focusing on the exchange of the exploration results into socially and mechanically important settings. In particular, RoboCup Rescue focuses on the plan of frameworks to look and protect for huge scope catastrophes. Here we center around the salvage robot alliance that focuses on the plan of robots looking through casualties in an obscure climate addressing a debacle situation. This sort of use gets logical difficulties, identified with the vulnerability about the climate, that are absent in the soccer classes. The test set up, called field, is being created in close collaboration with USAR. The fields have effectively been utilized in different investigations (counting RoboCup and AAAI salvage completions) and these days address a reference for trial assessment of the exhibition of salvage robots. The current point of the opposition is twofold: portability and self-sufficiency. Concerning the previous, the examination is centered on the mechanical plan that permits the robot to defeat the snags present in the climate; the last is worried about the plan of robots that can self-sufficiently investigate the climate, potentially working in a group, assemble the guide, discover the people in question and find them in the guide.

Two Italian groups take part in these contests since 2004: the first from SIED Lab, inside a coordinated effort between "Istituto Superiore Antincendi" and the University of Rome "La Sapienza"; the second one from the ALCOR lab of the University of Rome "La Sapienza", which fostered a model-based way to deal with the leader control of a salvage meanderer, winning the third honor in 2004. The RoboCup movement contributed and profited with the consequences of the examination project Simulation and Robotics Systems for Operations in Emergency Scenarios (SRSOES 2003-2005), subsidized by Italian MIUR 3.

Space Robotics

The point of the task An Intelligent System for the Supervision of Autonomous Robots in Space, subsidized by the Italian Space Agency (ASI) during years 1997-2000, is the utilization of AI methods to the plan and acknowledgment of room advanced mechanics frameworks for planetary investigation missions that require an expanding self-sufficiency. Specifically, the point of this undertaking has been the use of AI strategies to the plan and

acknowledgment of a compelling and adaptable framework for the management of the ASI mechanical arm SPIDER.

The undertaking was composed by the unit at the University of Palermo. Subproject units were the Universities of Roma "La Sapienza", Torino, Genova, Parma, and the examination communities ISTC-CNR Roma and IRST-ITC Trento. The logical goal of the venture is the plan and advancement of a savvy framework ready to oversee self-sufficient robots in space. The framework depends on a multiagent design in which each square is a product specialist interfaced with the remainder of the framework. This plan decision is roused by high adaptability, specialist compatibility with subsequent simple improvement of the design, reuse of the relative multitude of specialists or part of them, or of the actual engineering. The engineering has been planned by remembering the ASI missions; however it is completely broad and the single modules and the entire design might be effectively reconfigured for the management of other mechanical frameworks. The venture pointed toward understanding a creative examination item, and it is corresponding to ASI exercises.

Robotics for Elderly and Impaired People

The objective of the undertaking RoboCare4 supported by Italian Ministry of Education, University and Research (MIUR) from 2002 to 2006 is to fabricate a multi-specialist framework which creates client administrations for human help. The framework is carried out on an appropriated and heterogeneous stage, comprising of an equipment and programming model. The undertaking, as of now running, is composed by the ISTC-CNR Roma, subproject units are at the Universities of Genova, Torino, Bologna, Parma, Roma "La Sapienza", and at the CNR research focuses of Genova, Palermo, and Milano.

The utilization of self-ruling mechanical technology and conveyed processing innovations comprises the reason for the execution of various administrations in a climate with older individuals, for example, a medical care foundation or a home climate. The way that mechanical segments, wise frameworks and individuals are to act in a helpful setting is the thing that makes the investigation of such a framework testing, for research and furthermore according to the innovation coordination perspective.

The undertaking is coordinated in 3 errands: the improvement of a HW/SW structure to help the framework; the investigation and execution of a boss specialist; acknowledgment of mechanical specialists and innovation reconciliation. Close by the above research assignments, normal ease of use and worthiness issues are examined, adding to the execution of SW improvement, representation and recreation apparatuses for multi-robot frameworks.

REFERENCES

- R. C. Arkin. Just what is robot architecture anyway? Turing equivalency versus organizing principles.In AAAI Spring Symposium on Lessons Learnedfrom Implemented Software Architectures for PhysicalAgents, 1995.

- Bicchi, and G. Tonietti. Fast and soft arm tactics: Dealing with the safety-performance tradeoff inrobot arms design and control. IEEE Robotics andAutomation Magazine 11(2), 2004.

- Bonarini, M. Matteucci, and M. Restelli. Fillingthe gap among coordination, planning, and reactionusing a fuzzy cognitive model. In RoboCup 2003:Robot Soccer World Cup VII, pages 662–669, Berlin, Heidelberg, 2003. Springer-Verlag.

- R. A. Brooks. A robust layered control system for amobile robot. IEEE Journal of Robotics and Automation,2(1), 1986.

- Castelpietra, A. Guidotti, L. Iocchi, D. Nardi, and R. Rosati. Design and implementation of cog-nitive soccer robots. In RoboCup 2001: Robot SoccerWorld Cup V, pages 312–318, Berlin, Heidelberg,2002. Springer-Verlag.

- Chella, M. Frixione, and S. Gaglio. Understanding dynamic scenes. ArtiÞcial Intelligence, 123:89–132,2000.

- Chella, S. Gaglio, and R. Pirrone. Conceptualrepresentations of actions for autonomous robots.Robotics and Autonomous Systems, 34:251–263,2001.

- L. Chittaro and A. Montanari. Efficient temporal reasoningin the cached event calculus. Computational Intelligence Journal, 12(3):359–382, 1996.

- S. Coradeschi and A. Saffiotti. An introduction tothe anchoring problem. Robotics and Autonomous Systems, 43(2-3):85–96, 2003.

- P. I. Corke. Visual Control of Robots: High-Performance Visual Servoing. Wiley, New York,1996.

✓ G. De Giacomo, L. Iocchi, D. Nardi, and R. Rosati. A theory and implementation of cognitive mobilerobots. Journal of Logic and Computation, 5(9):759–785, 1999.

✓ R. Fikes and N. Nilsson. STRIPS: A new approach tothe application of theorem proving to problem solving. Artificial Intelligence, 2, 1971.

✓ Finzi and F. Pirri. Combining probabilities, failuresand safety in robot control. In Proceedings of IJCAI-01, pages 1331–1336, 2001.

✓ E. Giunchiglia, G. N. Kartha, and V. Lifschitz. Representingaction: Indeterminacy and ramifications. Artificial Intelligence, 95(2):409–438, 1997.

✓ J. Hallam and H. Bruyninckx. An ontology ofrobotics science. In H.I. Christensen, editor, EuropeanRobotics Symposium 2006, pages 1–14, Berlin, Heidelberg, 2006. Springer-Verlag.

✓ L. Iocchi, D. Nardi, M. Piaggio, and A. Sgorbissa.Distributed coordination in heterogeneousmulti-robot systems. Autonomous Robots, 15:155–168, 2003.

✓ H. Kitano and M. Asada. Robocup humanoid challenge: That's one small step for a robot, one giant leap for mankind. In Proc. of IEEE/RSJ International Conference on Intelligent Robots and Systems 1998 (IROS Õ98), pages 419–424, 1998.

✓ H. Kitano et al. Robocup-rescue: Search and rescue for large scale disasters as a domain for multiagent research. In Proceedings of IEEE Conference on Man, Systems, and Cybernetics(SMC-99), 1999.

✓ Y. Lesperance, H.J. Levesque, F. Lin, D. Marcu, R. Reiter, and R. B. Scherl. A logical approach to high-level robot programming. In AAAI FAll Symposium on Control of the Physical World by Intelligent Systems, 1994.

✓ H.-H. Nagel. Steps toward a Cognitive Vision System. AI Magazine, 25(2):31–50, 2004.

✓ Nardi et al. ART-99: Azzurra Robot Team. In RoboCup-99: Robot Soccer World Cup III, pages 695–698. Berlin, Heidelberg, 1999. Springer-Verlag.

✓ N.J. Nilsson. Shakey the robot. Technical Report 323, SRI International, Menlo Park, CA, 1984.

✓ S. Nolfi and D. Floreano. Evolutionary Robotics. MIT Press, Cambridge, MA, 2000.

✓ Pagello et al. RoboCup-2003: New Scientific and Technical Advances. AI Magazine, 25:81–98, 2004.

✓ R. Pfeifer and C. Scheier. Understanding Intelligence. MIT Press, Cambridge, MA, 1999.

✓ M. Piaggio. Classifying robot software architecture. AI*IA Notizie, 4, 1998.

✓ R. Reiter. Knowledge in action: Logical foundations for describing and implementing dynamical systems. MIT Press, Cambridge, MA, 2001.

✓ R. Reiter and A. Mackworth. A logical framework for depiction and image interpretation. ArtiÞcial Intelligence, 41:125–155, 1989.

✓ S.J. Russell and P. Norvig. ArtiÞcial Intelligence: A Modern Approach. Pearson Education, 2003.

✓ L. Sciavicco and B. Siciliano. Modelling and Control of Robot Manipulators, 2nd ed. Springer-Verlag, Berlin Heidelberg, 2000.

✓ M. Shanahan. Perception as abduction: Turning sensor data into meaningful representation. Cognitive Science, 29:103–134, 2005.

✓ L. Steels. Towards a theory of emergent functionality. In J.A. Meyer and S.W. Wilson, editors, From Animals to Animats I, Cambridge, MA, 1991. MIT Press.

✓ M. Veloso,W. Uther,M. Fujita, M. Asada, and H. Kitano. Playing soccer with legged robots. In Proceedings of IROS-98, Intelligent Robots and Systems Conference, Victoria, Canada, October 1998.