An Open-Source Simulator for Cognitive Robotics Research: The Prototype of the iCub Humanoid Robot Simulator

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ABSTRACT

This paper presents the prototype of a new computer simulator for the humanoid robot iCub. The iCub is a new open-source humanoid robot developed as a result of the "RobotCub" project, a collaborative European project aiming at developing a new open-source cognitive robotics platform. The iCub simulator has been developed as part of a joint effort with the European project "ITALK" on the integration and transfer of action and language knowledge in cognitive robots. This is available open-source to all researchers interested in cognitive robotics experiments with the iCub humanoid platform.

Keywords

Open-Source, Simulator, iCub humanoid robot, cognitive robotics.

1. INTRODUCTION

Computer simulations play an important role in robotics research. Despite the fact that the use of a simulation might not provide a full model of the complexity present in the real environment and might not assure a fully reliable transferability of the controller from the simulation environment to the real one, robotic simulations are of great interest for cognitive scientists [18]. There are several advantages of robotics simulations for researchers in cognitive sciences. The first is that simulating robots with realistic physical interactions permit to study the behavior of several types of embodied agents without facing the problem of building in advance, and maintaining, a complex hardware device. The computer simulator can be used as a tool for testing algorithms in order to quickly check for any major problems prior to use of the physical robot. Moreover, simulators also allow researchers to experiment with robots with varying morphological characteristics without the need to necessarily develop the corresponding features in hardware [1]. This advantage, in turn, permits the discovery of properties of the behavior of an agent that emerges from the interaction between the robot's controller, its body and the environment. Another advantage is that robotic simulations make it possible to apply particular algorithms for creating robots' controllers, such as evolutionary or reinforcement learning algorithms [12]. The use of robotics simulation permits to drastically reduce the time of the experiments such as in evolutionary robotics. In addition, it makes it possible to explore research topics like the co-evolution of the morphology and the control system [1]. A simulator for the iCub robot magnifies the value a research group can extract from the physical robot, by making it more practical to share a single robot between several researchers. The fact that the simulator is free and open makes it a simple way for people interested in the robot to begin learning about its capabilities and design, with an easy "upgrade" path to the actual robot due to the protocol-level compatibility of the simulator and the physical robot. And for those without the means to purchase or build a humanoid robot, such small laboratories or hobbyists, the simulator at least opens a door to participation in this area of research.

The iCub simulator is currently being used by both the RobotCub and the ITALK project partners for preliminary experiments on the simulator robot, and subsequent testing with the physical robots.

2. ICUB SIMULATOR DEVELOPMENT

The iCub simulator has been designed to reproduce, as accurately as possible, the physics and the dynamics of the robot and its environment. The simulated iCub robot is composed of multiple rigid bodies connected via joint structures. It has been constructed collecting data directly from the robot design specifications in order to achieve an exact replication (e.g. height, mass, Degrees of Freedom) of the first iCub prototype developed at the Italian Institute of Technology in Genoa. The environment parameters on gravity, objects mass, friction and joints are based on known environment conditions.

2.1 Open-Source Approach

The iCub simulator presented here has been created using open source libraries in order to make it possible to distribute the

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Software Architectures for Humanoid Robotics Lorenzo Natale,Tamim Asfour,Fumio Kanehiro,Nikolaus Vahrenkamp,2018-10-11 Simulation, Modeling, and Programming for Autonomous Robots Itsuki Noda,Noriako Ando,Davide Brugali,James J. Kuffner,2012-10-20 This book constitutes the refereed proceedings of the Third International Conference on Simulation Modeling and Programming for Autonomous Robots SIMPAR 2012 held in Tsukuba Japan in November 2012 The 33 revised full papers and presented together with 3 invited talks were carefully reviewed and selected from 46 submissions Ten papers describe design of complex behaviors of autonomous robots 9 address software layers 8 papers refer to related modeling and learning The papers are organized in topical sections on mobile robots software modeling and architecture and humanoid and biped robots **Simulation, Modeling, and Programming for Autonomous Robots** Noriako Ando,Stephen Balakirsky,Thomas Hemker,Monica Reggiani,Oskar von Stryk,2010-11-05 Why are the many highly capable autonomous robots that have been promised for novel applications driven by society industry and research not available day despite the tremendous progress in robotics science and systems achieved during the last decades Unfortunately steady improvements in speci c robot abilities and robot hardware have not been matched by corresponding robot performance in real world environments This is mainly due to the lack of vancements in robot software that master the development of robotic systems of ever increasing complexity In addition fundamental open problems are still awaiting sound answers while the development of new robotics applications s fersfromthelackofwidelyusedtools libraries andalgorithmsthataredesigned in a modular and performant manner with standardized interfaces Simulation environments are playing a major role not only in reducing development time and cost e g by systematic software or hardware in the loop testing of robot performance but also in exploring new types of robots and applications H ever their use may still be regardedwith skepticism Seamless migrationof code using robot simulators to real world systems is still a rare circumstance due to the complexity of robot world sensor and actuator modeling These challenges drive the quest for the next generation of methodologies and tools for robot development The objective of the International Conference on Simulation Modeling and ProgrammingforAutonomous Robots SIMPAR is to o er a unique forum for these topics and to bring together researchersfrom academia and industry to identify and solve the key issues necessary to ease the development of increasingly complex robot software **Evolutionary Humanoid Robotics** Malachy Eaton,2015-02-02 This book examines how two distinct strands of research on autonomous robots evolutionary robotics and humanoid robot research are converging The book will be valuable for researchers and postgraduate students working in the areas of evolutionary robotics and bio inspired computing Embodied and grounded cognition Anna Borghi,Diane Pecher,2012-01-01 In the last 10 15 years the embodied and grounded cognition approach has become widespread in all fields related to cognitive science such as cognitive and social psychology neuroscience philosophy anthropology computational modelling and robotics

According to this approach our cognitive activity is grounded in sensory motor processes and situated in specific contexts and situations Therefore in this view concepts consist of the reactivation of the same neural pattern that is present when we perceive and or interact with the objects they refer to In the same way understanding language would imply forming a mental simulation of what is linguistically described This simulation would entail the recruitment of the same neurons that are activated when actually acting or perceiving the situation action emotion object or entity described by language In the last years a lot of evidence has been collected in favour of EC and GC view The aim of this Research Topic is twofold First it intends to give an idea of the field of embodied and grounded cognition in its broadness We therefore intend to invite scientists of different disciplines anthropology philosophy linguistics cognitive and social psychology neuroscience computer science to submit their proposals The second aim of this Research Topicis to focus on some challenges that in our opinion embodied and grounded theories of cognition need to face First we believe that one important challenge for EC and GC views is to account for the way the so called abstract concepts and abstract words are represented Evidence on the representation of concrete concepts and words is compelling whereas evidence on abstract concepts representation is still too scarce and limited to restricted domains We therefore welcome proposals dealing with this complex issue Second we think that embodied and grounded theories of cognition would need to formulate more precise hypotheses and that in general within the field a larger theoretical effort should be made It is striking that even if a lot of work in the field of computational modelling and robotics starts from an embodied approach experimental and modelling work on embodied cognition remain somehow separate We therefore invite researchers to submit papers proposing models which might help to explain phenomena as well as to constrain and specify in more detail the predictions and the claims advanced within the framework of EC and GC theories **Multibody Dynamics** Josep M. Font-Llagunes,2016-04-12 This book includes selected papers from the ECCOMAS Thematic Conference on Multibody Dynamics that took place in Barcelona Spain from June 29 to July 2 2015 By having its origin in analytical and continuum mechanics as well as in computer science and applied mathematics multibody dynamics provides a basis for analysis and virtual prototyping of innovative applications in many fields of contemporary engineering With the utilization of computational models and algorithms that classically belonged to different fields of applied science multibody dynamics delivers reliable simulation platforms for diverse highly developed industrial products such as vehicle and railway systems aeronautical and space vehicles robotic manipulators smart structures biomechanical systems and nanotechnologies Performance Evaluation and Benchmarking of Intelligent Systems Raj Madhavan,Edward Tunstel,Elena Messina,2010-04-29 To design and develop capable dependable and affordable intelligent systems their performance must be measurable Scienti c methodologies for standardization and benchmarking are crucial for quantitatively evaluating the performance of eme ing robotic and intelligent systems technologies There is currently no accepted standard for quantitatively measuring the performance of these systems against user de ned requirements and

furthermore there is no consensus on what obj tive evaluation procedures need to be followed to understand the performance of these systems The lack of reproducible and repeatable test methods has precluded researchers working towards a common goal from exchanging and communic ing results inter comparing system performance and leveraging previous work that could otherwise avoid duplication and expedite technology transfer Currently this lack of cohesion in the community hinders progress in many domains such as m ufacturing service healthcare and security By providing the research community with access to standardized tools reference data sets and open source libraries of solutions researchers and consumers will be able to evaluate the cost and be ts associated with intelligent systems and associated technologies In this vein the edited book volume addresses performance evaluation and metrics for intel gent systems in general while emphasizing the need and solutions for standardized methods To the knowledge of the editors there is not a single book on the market that is solely dedicated to the subject of performance evaluation and benchmarking of intelligent systems

Proceedings of the ... International Symposium on Micromechatronics and Human Science ,2000 **RoboCup ...** ,2004 **Aerospace Medicine and Biology** ,1990 A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in Scientific and technical aerospace reports STAR and International aerospace abstracts IAA **Documentation Abstracts** ,1991

Building the iCub Mindware: Open-source Software for Robot Intelligence and Autonomy Daniele Pucci,Vadim Tikhanoff,Ugo Pattacini,Maxime Petit,Lorenzo Jamone,2020-02-25 Intelligence and autonomy are among the most extraordinary capacities blossomed by human evolution Yet endowing humanoid robots with these two crucial capabilities is still one of the biggest problems for the robotics community despite decades of research On the software side algorithms for artificial intelligence are still at an embryonic stage On the hardware side robotic actuators are a far cry from the muscular human system in terms of flexibility and adaptability which in turn reduces autonomy and robustness Underneath the nature of algorithms for intelligence and technology for autonomy the importance of efficient scalable implementations of robust software goes without saying Among the large variety of humanoid robots the iCub has emerged as one of the most diffused research platforms It has been developed as part of the RobotCub EU project and subsequently adopted by more than 35 laboratories worldwide Collaborations across laboratories are encouraged by writing code and libraries openly available As a consequence iCub is considered to be the ideal platform for experimenting and advancing open source software for research in several domains ranging from motor control to cognitive systems Government Reports Announcements & Index ,1995

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Government Reports Annual Index ,1986 *Conference Papers Index* ,1987 **Design and Implementation of an Autonomous Robotics Simulator** Adam Carlton Harris,University of North Carolina at Charlotte. Department of Electrical

and Computer Engineering,2011 Robotics simulators are important tools that can save both time and money for developers Being able to accurately and easily simulate robotic vehicles is invaluable In the past two decades corporations robotics labs and software development groups have released many robotics simulators to developers Commercial simulators have proven to be very accurate and many are easy to use however they are closed source and generally expensive Open source simulators have recently had an explosion of popularity but most are not easy to use This thesis describes the design criteria and implementation of an easy to use open source robotics simulator SEAR Simulation Environment for Autonomous Robots is designed to be an open source cross platform 3D 3 dimensional robotics simulator written in Java using jMonkeyEngine3 and the Bullet Physics engine Users can import custom designed 3D models of robotic vehicles and terrains to be used in testing their own robotics control code Several sensor types GPS triple axis accelerometer triple axis gyroscope and a compass have been simulated and early work on infrared and ultrasonic distance sensors as well as LIDAR simulators has been undertaken Continued development on this project will result in the fleshing out of the SEAR simulator

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