MOTOR CONTROL AND MOTOR LEARNING OF THE FABLE MODULAR ROBOT BY THE COMBINATION OF MACHINE LEARNING AND CEREBELLAR-LIKE NEURAL NETWORKS

Ms. Vasundhara Manda[1]
3rd Year Student,
Department of Computer Science,
SV U CM & CS, Tirupati.

Prof. S. Rama Krishna[2],
Professor,
Department of Computer Science,
SV U CM & CS,, Tirupati.

Abstract: In this paper bio inspired control architecture for the motor control and motor learning of a real modular robot is we scaled up. Our approach is that the Locally Weighted Projection Regression algorithm (LWPR) and a Cerebellar microcircuit coexist, in the form of a Unit Learning Machine. The LWPR algorithm optimizes the input space and learns the internal model of a single robot module to command the robot to follow a desired trajectory with its end-effectors. The Cerebellar-like microcircuit refines the LWPR output delivering corrective commands. In this we contrasted distinct Cerebellar-like circuits including analytical models and spiking models implemented on the SpiNNaker platform, it is showing promising performance and robustness results.

INTRODUCTION

Understanding the human brain is one of the best and most appealing challenges facing scientific research. So that's why, initiatives such as the Human Brain Project[1] (HBP) was conceived to encourage the delivery of beneficial breakthroughs for society and industry. The HBP gives the effort of numerous researches. In particular, we focused on neurorobotics.

Robots lack the adaptability and precision of human beings towards uncertain or unknown environments. In contrast, the brain accomplishes tasks in an admirable way allowing smooth movements with low power consumption.

As a result, studying how we control our bodies in uncertain or unknown environments, how we coordinate smooth movements and the mechanisms of motor control and motor learning of the central nervous system (CNS) has become of interest towards the development of bio-inspired autonomous robotic systems.

THE CEREBELLUM

Among the various parts of the brain, the cerebellum stands out due to its key role in modulating accurate, complex and coordinated movements, acting as a universal learning machine[2]. Its contributions include the neural control of bodily functions, such as postural positioning, balance or coordination of movements over time[2]. Thus, understanding and mimicking the Cerebellar mechanisms through bio-inspired architectures are interesting processes in the development of innovative robotic systems capable of carrying out complex and accurate tasks in varying situations.

METHODS AND REQUIREMENTS

In this paper we gave the modular robot, our modular control approach and the utilization of machine learning techniques. They are

- The modular robot: Fable
- The modular approach
- The bio-inspired modular control architecture
- The LWPR algorithm

THE MODULAR ROBOT: FABLE

The robotic platform is the modular robot called Fable[7]. Fable is based on the combination of self-contained modules which can work independently or collaborate in modular configurations. Because of a low lag radio communication link to the modules the user can program the distributed robot modules at different levels of abstraction as if they were centralized and connected directly to the computer. To do so, the communication is done via a radio dongle addressing each module with an ID and a radio channel.

THE MODULAR APPROACH

The studies of scientific research on the cerebellum describe it as a set of adaptive modules, called micro complexes, which represent the minimal functional unit and show a uniform almost crystalline microcircuitry[10]. Thus, we decided to use its structure to control a robot module in a generic manner.

Two micro complexes were used to command the joints of a 2-DoF module. Each Cerebellar output was linked to one joint as it happens in our body, where one motor cell commands one motor unit.

THE BIO-INSPIRED MODULAR CONTROL ARCHITECTURE

To perform the motor control and learning of a fable module, we choose the Adaptive Feedback Error Learning (AFEL).

The trajectory generation block generates the desired joint angles and velocities $(Qd, \dot{Q}d)$ by inverse kinematics.

On the one hand, the AFEL scheme guarantees the stability of the system by means of a control loop in which a Learning Feedback (LF) controller[3] is implemented. The LF overcomes the lack of a precise robot morphology dynamic model ensuring stability and adjusting its output torque through a learning rule after consecutive iterations of the same task. Its gains were heuristically tunes to $Kp = 7.5$, $Kv = 6.4$ and $Ki = 1$ for the Fable module.

THE LWPR ALGORITHM

The LWPR algorithm[4] creates and combines N linear local models and feeds the sensor motor inputs of the robot including desired and real values to them. Thereafter, the LWPR incrementally divides this sensor motor input space into a set of receptive fields (RFs) performing an optimal function approximation. The RFs are represented by a Gaussian weighting kernel which computes a weight in each k-th local unit, for each xi data points according to its distance to the center of the kernel.

We select LWPR algorithm for three reasons:

First to optimize the input space to enhance learning speed and accuracy; second since it can substitute and optimize the role of a certain group of cells of the cerebellum, called granule cells; and third due to its capability of learning incrementally on-line.

RESULT

The control architecture tested on using the three Cerebellar model cases described by commanding the robot to trace out a circular trajectory with its end-effectors as depicted. The tests considered the normalized mean square error (nMSE) of the position of the joints with respect to the desired positions. First, the performance test consisted in following a circular trajectory with constant amplitude and spin frequency Secondly, we carried out two robustness tests where we considered trajectories that varied they amplitude keeping the spin frequency constant, and thereafter, trajectories that kept the amplitude constant but varied their spin frequency (0.5-1Hz).

CONCLUSION

In this paper we combined the LWPR algorithm and a Cerebellar circuit for the motor control and learning of a real robot module. Furthermore, we implemented three distinct Cerebellar models: two non-spiking and one spiking using the neuromorphic SpiNNaker platform. By comparing to Step 1, Step 2 shows better results in the performance test while keeping similar results in both robustness tests. Step 3 did not show any improvements with respect to the non-spiking models, but since its circuitry was quite simple there is much more scope for promising further research. Future research will gives the potential of more detailed spiking models where inhibitory and recurrent synapses will take place and explore the control of several robot modules using SpiNNaker.

REFERENCES

[1] Ailamaki, A., A. Alvandpour, K. Amunts, W. Andreoni, J. Ashburner, M. Axer, M. Baaden, and R. Badia. "The Human Brain Project: A Report to the European Commission”. *Lausanne: The HBP-PS Consortium* (2012).

[2] Ito, Masao. “Cerebellar circuitry as a neuronal machine.” *Progress in neurobiology* 78, no. 3 (2006): 272-303.

[3] Tolu, Silvia, Mauricio Vanegas, Niceto R. Luque, Jesús A. Garrido, and Eduardo Ros. “Bio-inspired adaptive feedback error learning architecture for motor control.” *Biological cybernetics* 106, no. 8-9 (2012): 507-522.

[4] Vijayakumar, Sethu, Aaron D'souza, and Stefan Schaal. "Incremental online learning in high dimensions." *Neural computation* 17, no. 12 (2005): 2602-2634.

[5] Baira Ojeda, Ismael; Tolu, Silvia; Pacheco, Moises; Christensen, David Johan; Lund, Henrik Hautop, 2017.

[6] Anna Baj-Rogowska, "Sentiment analysis of Facebook post: The Uber Case" In: 8thInternational Conference on Itelligent computing and Information System(ICICIS), 2017.

[7] Nicolai H. Egebjerg, Niklas Hedegaard, Gerda Kuum, "Big Social Data Analytics in football: Predicting spectators and Tv ratings from Facebook data" In: Big Data (BigData Congress), 2017 IEEE International Congress, 2017.

[8] Chang-Ling Hsu, Chia-Ming Liu, "A Big data fuzzy grey Relational analysis method for social post retrieval with an application to Facebook news groups" In: Applied System Innovation (ICASI), 2017 International Conference.

[9] B Akhilesh, Nagendra Kumar, "TRAFAN: Road traffic analysis using social media webpages" In: Communication Systems & Networks (COMSNETS), 2018 10th International Conference, 2018.

[10] Dongjin Choi, Chang Choi, "Reasearch for pattern analysis of Individual interest using SNS data: Focusing on Facebook" In: Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2014 Eighth International Conference, 2014

Authors Profile

MANDA VASUNDHARA, received Bachelor of Computer Science degree from VikramaSimhapuriUniversity ,Nellore in the year of 2013-2016. Pursuing Master of Computer Applications from Sri Venkateswara University, Tirupati in the year of 2016-2019. Research interest in the field of Computer Science in the area of machine learning , Cloud Computing and Software Engineering.

Prof Dr S. Ramakrishna, working as a Professor in Dept of Computer Science, Sri Venkateswara University College of Commerce Management and Computer Science, Tirupati, (AP)-India. Received M.Sc, M.Phil, M.Tech (IT) and Doctorate in Computer Science from S.V University, Tirupati, having 27 years experience in teaching field. Additional Assignments Working as Dean of Examinations for S.V University, Worked as Additional Convener for S.V University RESET Examinations, Worked as Coordinator for M.Sc Computer Science, Worked as BoS Chairman in Computer Science. Research Papers Published in National & International Journals :99, Total Number of Conferences participated :33, Total number of Books Published:7, Total number of Training Programs Attended : 3, Total number of Orientation & Refresher Courses Attended : 4.Number of research degrees awarded under my guidance :- M.Phil: 20,Ph.D:20.