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Author(s)	Pratama, Ferdian; Mastrogiovanni, Fulvio; Chong, Nak Young
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Description	

ERIS: Epigenetic Robot Intelligent System

Ferdian Pratama[1], Fulvio Mastrogiovanni[2], and Nak Young Chong[1]

Abstract— **We present our ongoing long-term project on how a robot may develop its own knowledge using Epigenetic Robot Intelligent System (ERIS), an epigenetic architecture that provides a robot the means to gather its own knowledge based on visual observation, and in particular, to deliver the knowledge for a personalized human-robot interaction. ERIS is inspired by the current Developmental Psychology studies, which core concept is based on human memory organization, and we have developed the interconnected knowledge models as different forms of Long-Term Memory, and the means to process them as a simulated Working Memory Model. ERIS is also capable of acquiring and revising relevant knowledge during the interaction process. To demonstrate these features, experiments are focused on the observation and analysis of two identical robots exposed with a different visual stimuli and interaction processes. The results show that the identical robots integrated with ERIS exposed to different interaction history and external stimuli, yields a personalized human-robot interaction experience.**

Index Terms— **Developmental Robotics, Subjectivity Principle, Epigenetic Architecture, Robot Past Experience, Progressive Knowledge Development, Developmental Psychology**

I. BACKGROUND

In the case of human-human interaction, there seems to be a varying interaction gap caused by the diversity of human personality, blends of characteristics, past experiences, and ultimately culture. This implies the onset of different meanings associated with the same "mental" symbol and therefore, an apparently similar communicative unit. Nevertheless, this is what makes a compelling and engaging interaction between humans. A persistent interaction gap exists due to the robot knowledge developed in a non-progressive way, resulting that human-led, stereotyped pattern of interactions may be established. This fact is supported by the survey of a long-term human-robot interaction, conducted by Leite [2] in a broad range of domain, such as health care and therapy domain, educational domain, in work environments and public spaces, and home environments. The survey includes the work by Salter et al. [3], Leite et al. [4], Gockley et al. [5], and Fernaeus et al. [6]. The persistent interaction gap present within those experiments is proven by the fact that people lose interest in the interaction easily after some time or after interacting with the same robot multiple times.

Toward the possibility of enriching human-robot interaction, we argue that a robot needs to have its own personality/character, and this must be supported by an architecture that defines the robot's personality. To achieve a unique, personalized robot (in terms of knowledge) with individual artificial personality, personal experience and social interaction are some of the elements that help in forming human personality, and we believe this also applies to robots. There are various researches attempting to achieve robot personality in terms of behavior and emotion, but few have discussed robot personality from the cognition perspective or even developmental perspective.

II. AIM

ERIS[1]is implemented as a ROS stack, and aside from the reasons above, the development of ERIS is mainly driven by the several points:

1) To develop an integrated epigenetic robot architecture that aim at long-term human-robot interaction process using an explicit model and characteristics of memory components;
2) To devise a holistic approach of epigenetic architecture with the capability to efficiently deal with contextual information, which is not available at currently available epigenetic architectures (i.e., the works proposed in [14–16]); and
3) To provide an open-source, transparent, and conceptually well-structured epigenetic architecture that provides robots the capability to independently and progressively gather knowledge, allowing them to have their own experience as the consequence.

Our vision is where robots in general, have the capability to exhibit self-developing robot knowledge for a more engaging and personalized human-robot interaction. Considering the fact that two identical robots exposed to different stimuli, it is natural to expect that different knowledge or experience are gained by each of the robots. Nevertheless, if we take human interaction into account within the self-development of the robot knowledge, two identical robots exposed to the same stimuli and have an interaction with human in a different fashion may result in a different experience. This idea is closely related to the Principle of Subjectivity, which has been addressed by Stoytchev in [1] as one of the fundamental properties that should be exhibited by epigenetic robots. Striving for our vision, we aim towards enhancing the human-robot interaction quality in general.

ERIS is currently a visual-oriented developmental framework, which captures and processes visual stimuli as the main input. A captured visual stimuli is defined as a *scene*, and represented as an *episode* to be consolidated as Episodic

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[1] Ferdian Pratama and Nak Young Chong are with the School of Information Science, Japan Advanced Institute of Science and Technology, Ishikawa, Japan `{ferdian, nakyoung}@jaist.ac.jp`

[2] Fulvio Mastrogiovanni is with the Department of Informatics, Bioengineering, Robotics and Systems Engineering (DIBRIS), University of Genoa, Italy `fulvio.mastrogiovanni@unige.it`

[1] The code is available at https://github.com/ferdianap/eris

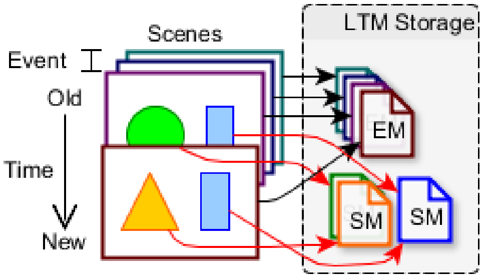


Fig. 1: Representation of objects and events, and their relations.

Memory in the Long-Term Memory storage. Consolidated episodes may defines *events* in a subjective fashion. Figure 1 depicts the relations of objects, scene, and episodes. Two ROS packages have been implemented: ERIS core package and ViSor package (Visual Stimuli Processor), which depicted in Figure 2 and Figure 3, respectively. The ERIS package is mainly manages the robot memories, and the ViSor package processes captured scenes and pass them to be consolidated by the ERIS package.

III. METHOD

We briefly describe the experimental scenario designed to emphasize the features introduced previously. The target robot platform is Baxter, a dual-arm manipulator from Rethink Robotics. The robot workspace is constituted by a table where we located objects with various shapes and colors. The camera integrated in the Baxter's left hand is directed towards the objects, and kept at a fixed configuration. Two independent experiments are conducted, and in each experiment, Baxter is treated and analyzed as two different robots, by integrated with ERIS and exposed to different stimuli, and receive different treatment from a human as part of the interaction.

Each experiment is consists of two main phases: (1) progressive knowledge acquisition; (2) memory retrieval through interaction. Phase 1 represents the capability of dealing with the changes within the environment, and during this phase, Baxter performs pick and place with respect to the objects within the workspace. Phase 1 is concluded when the last visual stimuli captured. Epigenetic robots should be able to gather knowledge, and at the same time having an interaction with the external world. Therefore, as the interaction process where human can pose questions to Baxter, phase 2 may occurs at any time, including during the execution of phase 1. However, here we clearly draws a line between phase 1 and 2 to consider all the gathered knowledge and experience before the interaction processes.

We introduce three fundamental cases where the memory recollection may occurs during Phase 2. *Case 1* is where the memory recollection involves the visual stimuli only, and the only case that applies for both *conscious* and *unconscious* process. Here, *conscious* memory recollection process means the process occurs involves demand/request from external factor, i.e., human inquire Baxter whether it is familiar with the detected visual input. Meanwhile, *unconscious* memory recollection process means the process occurs with no explicit, external request, i.e., occurs during the progressive knowledge development process. *Case 2* involves only contextual information which provided to Baxter during the human-robot interaction. During case 2, human may provide lexical context to Baxter for the check of the familiarity status. *Case 3* deals with the combination of visual stimuli and given contextual information. During case 3, human may present objects and also provide an additional context to Baxter for the check of the familiarity status. For all the cases introduced, two kinds of familiarity experiment will be conducted, i.e., object familiarity and scene familiarity, which relationship has been clarified by Figure 1.

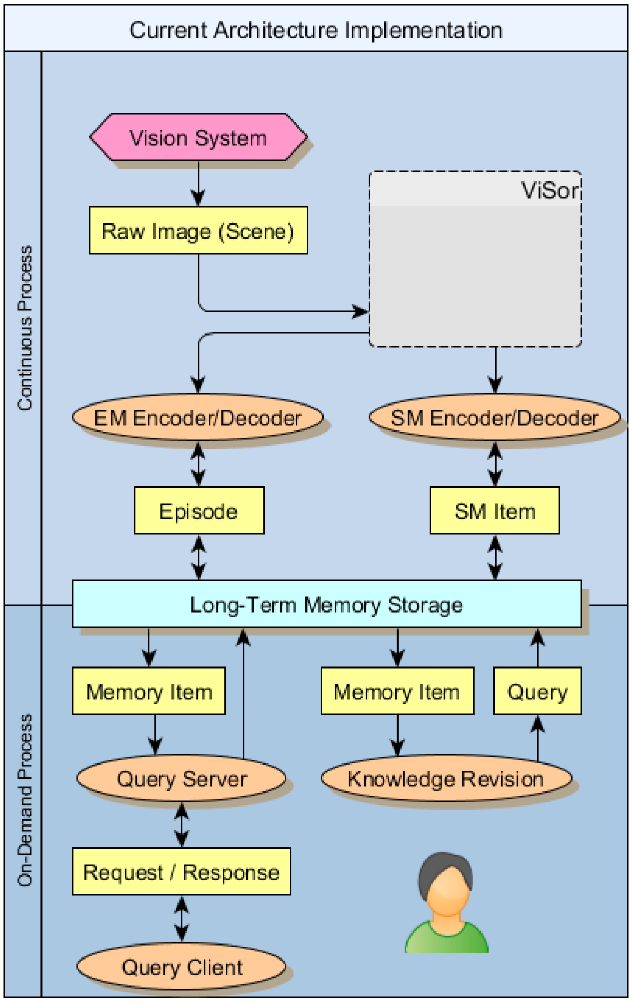


Fig. 2: Simplified ROS diagram of the architecture

IV. RESULTS

After the two robots (represented by one unit of Baxter) exposed with different stimuli and different interaction experience from a human, both robots yields various response

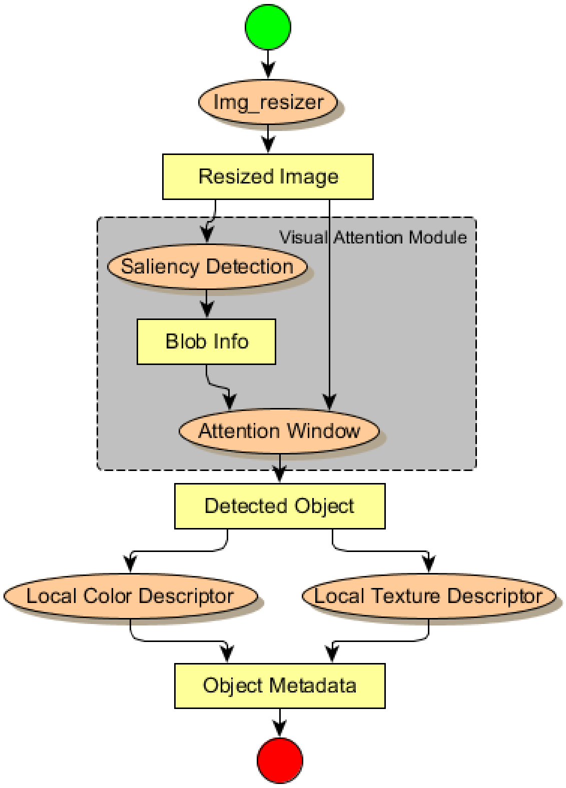
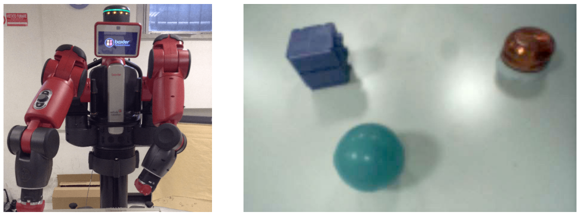


Fig. 3: Simplified ROS diagram of ViSor package



(a) Baxter (b) A captured scene

Fig. 4: Baxter and one of the scenes witnessed

depends on the past experience. This is closely related to *The Principle of Subjectivity* addressed by Stoytchev [1], which emphasizes the interaction history considering also past experience of each robot.

V. CONCLUSION

We introduced Epigenetic Robot Intelligent System (ERIS) as an open robot architecture aims to comply with the epigenetic paradigm, and eventually reducing the interaction gap between human and robot. ERIS is inspired from the current studies of Developmental Psychology, in particular the human memory organization, as *memory* is the key aspect of human knowledge development. With the capability of exhibiting progressive knowledge development and gaining robot personal experience coupled with social interaction with human, we believe ERIS could be a solid foundation for more sophisticated interaction phenomena to occurs during the human-robot interaction.

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