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Bio-Inspired Communication in Robots – a Review

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ABSTRACT

Communication between robots are crucial in situation where multi-robots combined to accomplish tasks in restricted environment in the absence of conventional communications or not possible. This paper review the communication modalities that are in current research and the various communication strategies used by biological species. This paper attempted to identify suitable communication strategy inspired from insects to be implemented in robots to handle some critical situations.

KEYWORDS : Robots, Bio-inspired Communication, Communication Strategy, insects, Living species

I. INTRODUCTION

Communication within robot is crucial in situations where group of robots are to be working together while performing specific task. Communication enablesthe coordination of multiple robots to co-operate with each other when they are geometrically spread in an environment. It can also be used to recall all the robots to gather to a centred location to perform a collective task such as rescue operation. Social insects are good inspiration for inter communication which does collective task such as locating and foraging food effectively usually in a heterogeneous environment. Insects used to communicate either acoustically, chemically, visual cues or vibration. Researchers inspired from Biological species Growing interests of study in the development of multi-robot systems adds increasing importance in communications within individual robot systems and it encourages the development of different communication modalities to be used in multirobot systems. Technological advancements made it realistic to consider the deployment of multi-robot systems consisting of large number of robots. Multi-robots are advantages compared over single robot that include low cost, highly robustness and parallelism. Tasks accomplishment in an inherently complex environment demand the use of a heterogeneous group of multi-robots as the required capabilities are considerable to be fulfilled by a single robot. As in the current situation where in from few robots to perform simple manipulation task to hundreds of thousands robots to perform multiple complex tasks necessitates inter co-ordination of robots and hence communication within them is increasingly important.

Communication within robots are categorised viz. in to implicit, explicit, state and goal based communications. Implicit communication is through change in the environment where in robot leave marks and trials that can convey other robots to recognise the changes caused in the environment by the marks and trails. Explicit communication is transmitting and receiving via some set of protocol or language as a medium which is an intentional communication which robot aware of it. This is less robust than the implicit as it needs to send information in a separate process. State communication in which robot will observe the state of the other robot's behaviour such as gesture or visual changesuch as robots following each other towards a light source. In the following section briefly review the current communication strategies used in various types of robots.

II. ROBOT COMMUNICATIONS

Enrico et al [1] presented the development of behaviour based implicit communication approach for PaSo Team a multi robot for soccer robotic competition system. In this the configuration of the environment depends on both the global task and the game dynamics provide the implicit information about the robots intention involved in the collective action that make the robots to co-operate. Mota et al [2] proposed an inter-robot communication framework of fundamental set of messaging protocol to communicate within a set of heterogeneous robots during the match for open robot-cub soccer team. This frame work introduces two vocabulary messaging scheme one to share the information about the game and the individual intentions of robots and second one enables the co-operation that will lead to more the complex movements involving several robots.Visual image recognition and wireless communications are other communication modalities used in multi robot team applications. Examples are rescue operations, surveillance and robotic games.

III. COMMUNICATION IN LIVING SPECIES

Nature offers very diverse set of options for communication within and between living species ranging from use of visual, acoustic, tactile and vibrations. Octopus and chameleon uses their capability of changing their body color. Octopus matches the shape and texture of its surroundings as well as releases ink which masks its location and activity though it is a color blind creature. Cuttlefish are well known for the "flashing" colours that are displayed on their bodies. It uses this color changing capability as a communication strategy during mating and fighting. During the mating season, male cuttlefish change their body colours in order to successfully attract a female. Some male cuttlefish have even been known to make themselves look like female cuttlefish in order to trick the dominant males and stealing their mates[3].Crabs communicate via dancing in order to find a mate. There are many different species of crabs, and they all look very similar. In order to distinguish between species, the males of each species display a different dance. These dances are used by males to attract a female mate. The dances include the male waving his large claw in specific patterns. Males also fight by waving their claws. This is not dangerous, and is more comparable to arm wrestling. In several species of American Fiddler Crabs, males use both visual and acoustical signals to find a mate. First, they perform their mating dance by waving their large claw in specific patterns. Then, at night, the male produces sounds from just inside his burrow to attract females. These sounds begin at a low rate, and then steadily increase in frequency.

Even though communication in several biological species have been

studied and translated to bio-inspired strategies for communication in robots, communication behaviours among insect kingdom however have received less attention. Insect kingdom offers very diverse communication strategies. In the following section various communication strategies used by the insects are briefly reviewed.

IV. COMMUNICATION IN INSECTS

Communication is an important aspect in biological insect life and for survival. In this section communication among social insects are briefly reviewed. Biological insects uses different modalities to establish social communication, such as sound, vision, chemical, tactile and more. Sound waves can travel a long distance and hence suitable for advertising signals [4]. Different insects communicate using a variety of signalling methods. These methods are with inclusion of sound, chemicals, visual cues and vibrations. This section review various methods signalling methods used by insects.

Insect Communication with sound: One of the most common ways of communication between insects is by means of using sound or a particular noise. Larger insects like crickets, grasshoppers, katydids and cicadas use airborne sound to communicate with each other[5]. This form of communication is more effective due their large size as compared with smaller insects due to the fact that the sound source should be at least one quarter of the sound wavelength for optimal power and range[6]. These insects h sound will have ears like human. They will have one ear on almost every part of the body unlike human has only two ears[7]. One of the best example insects uses acoustic communication and most studied is the field cricket uses pure tones [8].

The male and female crickets communicate with each other in an interesting manner by which male cricket sing a song which is recognised by the female that helped her to identify the location of male and to move toward. While cricket uses sound for effective communication it is not sure other predator listening. This is different other insects such as Ostriniafurnacalis or the Asian corn borer moth uses a type of "quiet" low intensity ultrasonic acoustical sexual communication [9].

Communication with Chemicals: In some insects, they use pheromones that made up of chemicals to communicate with each other. These pheromones acts like a triggering signal that is responsible for physiological changes in the insects. Both male and female produces different pheromones and physiological responses are based on different type of pheromones. Alkene in the hydrocarbon chain is found to be the main cause for the sexual and species identification [10].Foragers of Trigona this species uses pheromones between the food and nest to recruit workers and turn in to foragers and this pheromones are not only used find the direction and distance but also the altitude of the food from the nest [11].

Ropalidiasocial wasps are insects that use the advantages of pheromones to fight against the predator attack for their survival and pheromones released known as alarm pheromones. The amount of pheromones released is depends on the level of disturbance that causes fewer or larger number of wasps to fly out of the nest and ready for battle against the predator attack [12].

Communication with visual cues: An interesting communication method that is most commonly used in insect is in visual form. An example is in that of honey bee. For food that is far way than few 100 meters from bees cannot use pheromones or acoustical songs, it uses an interesting visual communication method called waggle dancing consists of sequence of dances that accurately convey the distances and location of the long distance food sources[13].

Communication with vibration: Small insect with their size constraint causing communication through acoustical sound is inefficient for mutual communication and vibrational communication is used and these vibrations generated by insects are generally in the frequency range 80 – 120 Hz. SenSarma et.al described how the hissing and piping noise of the honeybee is used as the way to raise alarm for the coordinated defense of the hives. [14].Rohrig et.al reported that similar type of vibrational sounds used for alarming observed in African fungus-growing termite which is used to inform other termites to stay insides their colonies until the dangerous condition has passed [15].

V. BIOINSPIRATION

Bioinspirtion or Biomimetics is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. Researchers are increasingly investigating and adopting a biomimetic approach. Biomimetics has given rise to new technologies inspired by biological solutions at macro and nanoscales. Humans have looked at nature for answers to problems throughout our existence. Bioinspirtion is often the result of biomimetic investigations where by natural mechanism is modified or altered to meet specific requirements.

Michael et al presented multi robot communication inspired through the behaviour recognition mechanism. A heterogeneous multirobot robot teams were enabled to co-operatively perform tasks without the use of conventional radio or acoustical communication modalities where in the team indicates the location of "mine like objects" exhibited by specific behaviour change. Teammates observe these action sequencesof other robot and learn the behaviour recognition and task assignment without the use of traditional communications methods[16]. Tim et al presented the prototype of a Honey Bee robot for the purpose of analysing the honey bee dance communication strategies. This work describes the hardware and software of a unique honey bee robot with a computer vision intended for experimental use by researchers. The honey bee dancing was analysed by high speed video cameras and used to enhance the design and with visual feedbacksystem to minimise the collision with other bees in a multi robot system [17]. There are many robots designed with communication modalities based on visual, acoustical and vibrational communications reported in literatures. Given the vast potential of vibration centred communication most of it airborne vibrational communication, it has been the least explored on substrate born vibrational communication.

VI. OPEN RESEARCH IN BIO-INSPIRD COMMUNICATIONS

In recent years it has been found that vibrational signals play a crucial role communication within insect groups. It is revealed from the study of insect communications has different mechanisms, tactics and systems. Inter-robot communication is vital in which larger groups of robots are involved in completing tasks such as rescue operations, surveillance and searching in hazardous environment. Communication is necessary for the coordination of multiple robots while being populated geometrically in the environment with communication constraints. Substrate born vibrational communication between multi-robotscould be helpful in these environments where mobility is restricted as well radio or optical communications were not possible if the robots are sharing same substrate.

VII. CONCLUSION

In this review paper communication modalities in multi robots and the communication strategies used in biological species were reviewed. Further various communication methods inspired from nature and used robots have been reviewed and further possibility of an research opening in bio inspired robot communication is explored.

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