ISSUES AND APPLICATIONS OF SWARM ROBOTICS

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ABSTRACT:
Swarm robotics is influenced from Swarm Intelligence. As Swarm in real life work with co-ordination for a specific goal, in the same way robots are expecting to work using artificial intelligence. This paper gives an overview of the Issues of swarm robotics and its application in various fields. Swarm robotics has a large area of applications. Since its introduction in 2000, several successful experimentations had been realized, and till now more projects are under investigations. This paper seeks to discuss issues and applications of this domain research.

Keywords: Swarm Robotics Advantages, Swarm Robotics Applications, Swarm Robotics Issues

1. INTRODUCTION

Artificial intelligence is inspired from natural intelligence. It is abstracting natural intelligence continuously and implementing in machine artificially, example is robotics. Swarm robotics is a technique in which a group of Robots work in a synchronized and coordinated manner to complete a specific task in a team. Swarm Robotics is influenced by idea of Swarm Intelligence and it implements the concept of natural swarms such as ant colonies, bee hives, flock of birds etc.

The term “swarm” is used to refer “a large group of locally interacting individuals with common goals”. Swarm robotics systems are characterized by simplicity of individuals, local sensing and communication capabilities, parallelism in task execution, robustness, scalability, heterogeneousness, flexibility and decentralized control. To analyze potential capabilities of robot swarms, swarm robotics has been studied in the context of producing different collective behaviours to solve tasks such as: aggregation, pattern formation, self-assembly and morphogenesis, object clustering, and assembling construction, collective search and exploration, coordinated motion, collective transportation, self-deployment, foraging and others(for detail tasks of robot read paper). The analysis of the results of these studies show that robot swarms are capable to solve these tasks satisfactory in controlled laboratory environments, at the same time there is no evidence of applying swarm robotics to solve real-life problems.
Swarm robotics has large domain of applications. It plays a vital role in solving real world complexities in significant way. Through our recent studies it is recognized that it is able to solve the problems and becoming closer to human needs. Although, it offers several advantages for robotic applications such as scalability, and robustness due to redundancy, few issues are also present here. The paper highlights the grand lines of the Issues area and its Applications.

2. SWARM ROBOTICS ADVANTAGES

The whole task can be divided into subtasks, assigned to individual member of the swarm so that they can work parallely to enhance the performance. Swarm robots work in a wider range area to accomplish a single goal task which is not possible in single robot system. If the single robot stops working in a group the task will not be halted, it will be done by the other members of the group. It means it is fault tolerant. It implements the distributed action, where a group of robots can actuate in different places at the same time. Parallelism means to accomplish a task concurrently. By using this technique task can be done more quickly than by a single robot. Robustness means no single point of failure for the system. If one system fails, the work doesn’t get stopped. Scalability means better performance as compared to centralized system, if it will have to cover wide area. Heterogeneousness means each members of the group is heterogeneous or different whose physical properties enable them to perform efficiently. Flexibility means easily reconfigured for the different applications. It has the ability to adopt different behaviour as per the need. Complex problems can be solved easily using a swarm of robots which might be impossible for a single robot. Cheap Alternative means each group member of swarm is simple robot which is cheaper than single powerful robot for each separate task. Stable, if one member fails in a group, the work won’t get stopped but their performance may degrade. It is useful for the task where the environment is dangerous. Economical benefits, swarm robotics cost low in designing, manufacturing as compared to single robot. Energy efficient means that the life time of the swarm is large. In an environment which has no fuelling facilities or where wired electricity is forbidden, the swarm robotics can be much useful than traditional single robot.

3. SWARM ROBOTICS APPLICATIONS

Agricultural area, by using this technique we can easily sow the seed, harvest, and store the grains in the warehouse, thus the work load of farmers gets decreased and they will be able give their time to think how the production can be increased. In Military applications, it is very much useful in detecting bomb which is most dangerous task for the humans and in these applications the need for security is perhaps self-evident. There is currently a great deal of a research taking place in the military use of robotics swarms. It is useful in traffic pattern in transportation system. In medical fields, a use of nano-robots moving through human veins and arteries (e.g. to fight certain types of cancer). It is useful in Post disaster relief where humans can’t reach we can easily introduce swarm robots individuals so we can use it where help is needed to search the target. We can also use it for deployment of distributed agents and for area coverage. To control mob swarm robots are the best choice as compared to humans. The swarm could response as quickly as possible to the emergency at hand. Robots may be used to perform tasks that are too dangerous or difficult for humans to implement directly (e.g. nuclear waste cleanup) or may be used to automate repetitive tasks that can be performed more cheaply by a robot than by the employment of a human (e.g. automobile production, shopping malls, hotels, etc) or may be used to automate mindless repetitive tasks that should be performed with more precision by a robot than by a human(material handling, material transfer applications, machine loading and unloading, processing operations, assembly and inspection). There are many industries which use
dangerous things like burning furnace, chemicals, making nuclear weapons etc. Here usage of swarms can reduce danger in such types of industries. As police agents also Swarm robots are beneficial. If we use it in survey purpose, the time and money both can be saved. Some of the hospital functions that might be automated include delivering linens, making beds, clerical duties such as entering patient records into computer file, delivering medicines and supplies from the hospital pharmacy and central supply and transporting patients for different services in the building. To handle events like social events, conducting conferences etc. swarms are useful. It can be applied for mining application. Sometimes mining work could be hazardous to human life so swarm robotics can be helpful. It also includes Collective exploration, shortest path finding and efficient task allocation, transport sub-task, which covers the important issue of collective transport. In hilly areas building roads is challenging for human but through swarm robotics road construction is easy and in the same way it is used in other engineering task also.

4. SWARM ROBOTICS ISSUES

Despite its potential to promote robustness, scalability and flexibility, swarm robotics has yet to be adopted for solving real-world problems. Various limiting factors are preventing the real-world uptake of swarm robotics systems. It is non-optimal because they are redundant and have no central control, lack of central control sometimes swarms behave independently. So swarm systems are inefficient. Swarms communicate with each other through messages but sometimes indirect communications are required like communicating through gesture, posture but swarms cannot communicate indirectly. Social insects like ants are able to find the shortest path by sensing the global environment but swarm robotics cannot sense global knowledge from environment so they cannot behave dynamically and it leads to deadlock of the whole system, so recovery is required to move from the stagnation. Complex swarm systems with rich hierarchies take time to boot up. Greater the complexities, the longer it takes to warm up. So it is non-immediate to so many tasks where active attention is needed. The swarm robotics behave strangely in unpredictable environment so desired task cannot be performed. Swarm robotics is homogenous systems. All robots behave in a similar manner. If it is required to work in an environment where heterogeneity is needed then we cannot use swarm. Because of internet limitations sometimes swarms might not be able to communicate so creation of their own network required for uninterrupted work, and it might be costly affair. As compared to single robot, swarms are cheaper but maintenance is high. Weather affects swarm robots severely, as weather changes create communication problem among robots. So coordination between robots is affected. Human cannot take part in group of robots as sometimes natural intelligence is required to accomplish the task. For each and every behavioural change we need to reprogram and it may affect the previous coding of the robot. So whole swarm are required to be recoded again. But it cannot bring the natural intelligence inside the swarm. A systematic and general way to design robot swarms is still missing, even though a few preliminary proposals have been made (Hamann and Worn, 2008; Berman et al., 2011; Brambilla et al., 2012). Securities issues are vital as Physical capturing of the robots are possible. There must be a provision to Identify and authenticate robot because a robot must know if it is interacting with a robot from its swarm or from an intruder robot. Communications can be intercepted or disturbed by an attacker. The major threats to military systems are from deliberate attacks on the robotic swarm. Such attacks may range from passive eavesdropping on communications, or monitoring
traffic to more sophisticated attacks where malicious robots may be injected into the swarm, much as viruses and Trojans in computer systems. Such sophisticated attacks may go unnoticed while the attacker manipulates data being processed by the swarm and possibly affects the emergent behaviour. Swarm robotics has the characteristic of fault tolerance. If few of the robots stop working even then swarm will work but performance slowdown can be seen. There is a system where a fix distance between robots should be maintained because they work on the rule of long range attraction and short range repulsion. If a number of robots become less then they would not be able to communicate and coordinate with each other according to above rule. So it challenges the fault tolerant feature.

5. CONCLUSION

This paper highlights the application and issues of swarm robotics. As swarm robotics have lot of features but still it is not widely acceptable to solve the real life problems. Further research is needed on robotic hardware to overcome hardware shortcomings that limit the functionality of current robotic systems. Central control limits the functionality of swarm robotics but there can be a robot among swarm which has the capability of sensing and repairing hardware defect of other robots and also has leadership quality to control and guide distributed autonomous robots in desirable situation. Further research on behavioural control is needed to discover effective ways to let a human operator interact with a robot swarm. Indirect communication might get enhanced in future. In the remote location and for the outhouse applications, to charge battery solar energy might become feasible in near future.

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