ABSTRACT

The research work reported in the thesis is focused on exploring applications of intelligent methodologies based on AI and evolutionary Soft Computing algorithms for automating the assembly planning tasks of generation and optimization of assembly sequences, robot task level planning and generation of robot program. The assembly sequence optimization is challenging because of the need to consider number of objectives, constraints and large search space that tends to increase exponentially as the number of parts in the assembly increases. Recently with the advent of nature-inspired computing, various evolutionary soft computing techniques have shown lot of promise in solving this optimization problem. However, there are still a number of research issues and challenges in application of these techniques like the problems of premature and slow convergence for complex assemblies, the computational time, the robustness/consistency, deviations in fitness of the solutions in the population from the optimum, and the problem of multi modal optimization for which the challenge is to maintain diversity in optimum solutions. With above challenges in mind, three novel discrete Flower Pollination Algorithm (FPA) based approaches have been proposed in this thesis. The first one is an FPA approach proposed for solving the multi-modal optimization problem. The second one is an improved FPA (IFPA) aimed at improving convergence speed and lowering run time. The third approach is hybrid GA-FPA based that has been found to improve consistency in finding the global optimum. Since FPA has been applied for the first time to a discrete optimization problem, modifications were needed to be made in the originally proposed continuous FPA. To demonstrate its working, examples taken from literature have been provided and the results compared with other well-known soft computing techniques. On comparison with respect to maximum number of unique optimum solutions that they can yield, the first of the proposed FPA approaches has been found to perform better than the other algorithms, but it appears to incur more computational time, whereas the proposed IFPA approach incurs the least time. In case of more complex assemblies, the GA-FPA could find the assembly sequence with the highest fitness value whereas none of the other algorithms could find the best sequence and further it was found to have the highest consistency.

Following the optimization of assembly sequences, the next step is to implement them for which it is necessary to generate the robot task level plan and the robot program. There are, however, several issues and challenges due to need for significant human expertise and domain knowledge in performing these tasks. Further, in today's era of mass customization, in order to quickly respond to design changes, it is necessary to evolve strategies for efficient and faster ways to generate and modify the robot programs that are labor intensive and time consuming in case of product assemblies with large number of parts. There is also need to develop knowledge-based systems

capable of emulating the human decision making. The literature review suggests that most of the reported work has not addressed the problems of generating task level instructions implementable irrespective of the robot controller and its implementation on the physical robot. Further there is not much reported work on automating robot program generation for assembly and its implementation. Keeping these in mind, a Knowledge-based system methodology has been proposed for automatically generating list of instructions to perform assembly irrespective of the robot controller by using the knowledge about different robot operations needed to translate the assembly operations in the sequence including sensory operations to locate the objects and manipulation operations. Its implementation has been shown using a vision assisted robotic system. Further another knowledge-based system methodology has been proposed for automatically generating executable programs in INFORM programming language of Motoman Industrial Robot by using knowledge about syntax and semantics of the programming language for robot control. For validation, their implementations have been carried out on an offline robot programming and simulation environment, MotoSim. Further, a knowledge-based system has been developed to automate the selection of tool/gripper and base part that constitute the input to the aforementioned assembly planning modules. A database has been built using Microsoft Access® to organize and store all the input data required by different assembly planning modules.

Keywords

Computer-aided assembly planning, Assembly sequence optimization, Flower Pollination Algorithm, Task level planning, Robot program generation, Knowledge-based system.