PROGRESS REPORT

THE EDINBURGH VERSATILE LAYOUT AND ASSEMBLY PROGRAM

by
A. Patricia Ambler
Department of Machine Intelligence
University of Edinburgh 6

A computer-controlled versatile layout and assembly system has recently been programmed at the School of Artificial Intelligence, University of Edinburgh. The equipment used, locally known as Freddy, consists of a moveable table, a mechanical hand suspended over the table and two fixed TV cameras, all connected via an 8K Honeywell 316 to a timeshared 128K ICL 4130 running POP-2 programs. The hand is fixed above the table but can be raised and lowered, and rotated about a vertical axis. It has two palms, with force sensors, which are parallel to each other, and can be tilted about a horizontal axis, and moved together and apart. There is an obliquely mounted, wide-angle TV camera which is used to scan the table, and a vertically mounted one which is used to examine in detail smaller areas of the table (See Figure 1). 6a

The layout and assembly program enables one to tip a boxful of toy parts into a heap on the table (Figure 4), and to leave the robot, unattended, to sort out the parts, choose those which are needed to make a particular toy, lay them out neatly on the table, and then assemble them into a completed toy. It takes about 1 1/2 hours per toy. In order to do this the robot has to be taught (a) how to recognize individual parts, and how to handle them and (b) how to assemble the toy. These two teaching processes both take 2-3 hours of interactive time. The heap smashing and layout program is able to deal with things going wrong. Sometimes a part is dropped when it is being moved, and sometimes an even worse than usual TV picture leads to the non-recognition of an object. The robot is able to recover. However, the assembly part of the system is not able to recover from unforeseen events. 6b

Finding Objects on the Table 6c

The table top is searched with the oblique camera. Objects on it are seen as white blobs on a black background. The robot works out their location on the table, using some arbitrary figure for their height. Objects seen in subsequent pictures are put into correspondence with the map so formed using not only their absolute positions, but also their relative positions. To do this, a graph matching program is used. This program is also used in object recognition when matching segments and holes.

Object Description and Recognition 6d

An object lying by itself on the table will be in one of several possible mechanically stable states. The robot is taught, by example, the appearance, under the vertical camera, of the object in each of these stable states. The learned description is

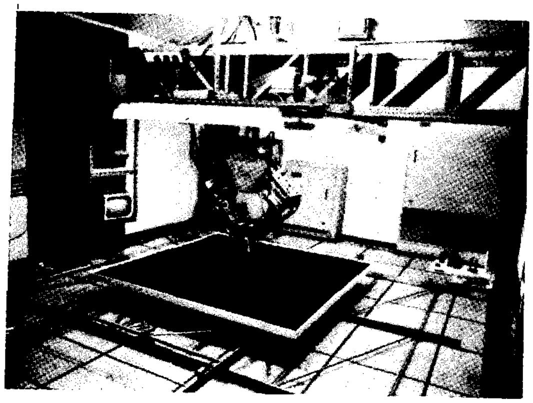

FIGURE 1

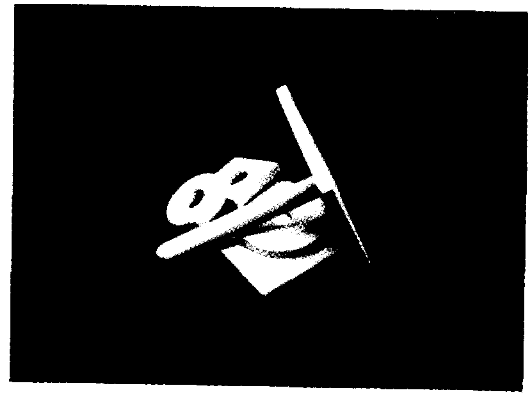

FIGURE 2

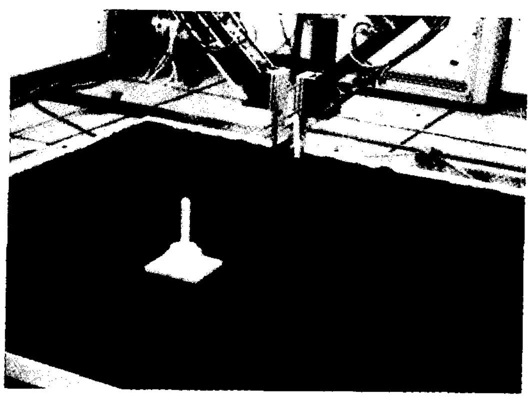

FIGURE 3

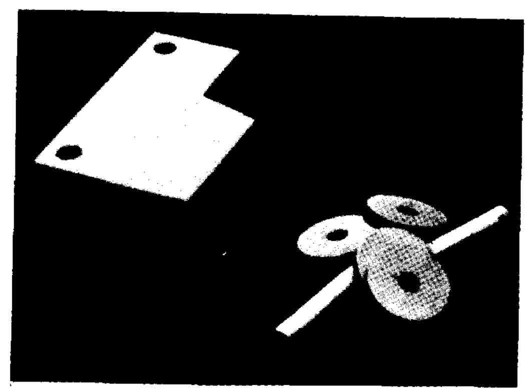

FIGURE 4

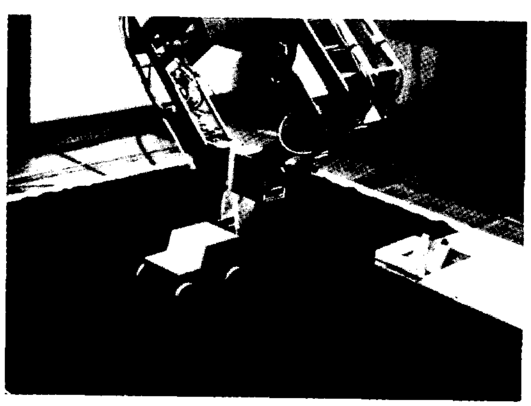

FIGURE 5

FIGURE 6

hierarchical, and includes, at the region level, details of the white blob on the black background of the table; at the hole level, the number and shape of any holes; at the outline level, the number, shape, and relations between curved and straight-line segments that have been fitted to the outline of the blob (Figure 6).

Having learned a visual description of an object lying on the table, the robot is shown how to handle it when it is in such a position. Freddy is shown, by example, how to grasp the object, how to turn it over into a standard stable state, and where to lay it on the table ready for assembly.

Recognition of an object involves matching the hierarchical description of the object as seen under the vertical camera (the actual description), with the learned description (the model description). Once it has been recognized as an object in a particular stable state, the robot will be able to work out how to pick it up and how to lay it out.

Heap Smashing 6e

If an object seen under the vertical camera is not recognized then it is treated as a heap, and the hands are used to break up the heap. The robot does not try to recognize individual objects in a heap, but tries to lift something out so that it can be put down on a clear part of the table and examined without interference. When breaking a heap, Freddy first tries to see a protrusion which can be grasped by the palms. If he can't find one, then he tries a blind grab at the heap, and if this fails to get anything, then he sweeps his hands through the heap to spread it over the table, and then tries to pick something up again. Objects which have not been recognized because of a poor TV picture will be treated as heaps and picked up and put down again and re-examined, so that they have a good chance of being properly recognized.

Assembly 6f

The assembly part of the program works blind, using only hand sensing. It is written interactively at instruction time using some basic moving and sensing operations and two higher-level ones. The higher-level operations are: constrained move--i.e., move in some particular direction until some opposing force is felt, while at the same time keeping in contact with the surface; and hole fitting--i.e., use a spiral pattern search to fit some protrusion into a hole.

The assembly of a toy car from a kit consisting of four wheels, two axles and a car body usually takes about 1/2 hour. A workbench is used, fixed to a corner of the table. It has a "vice" for holding wheels while axles are being fitted, and a wall to hold the car against while the second wheels are being fitted onto the axis (Figure 5).

A paper describing the system is to be presented at IJCAI-73 (Ambler, Barrow, Brown, Burstall, and Popplestone, "A Versatile, Computer-Controlled, Assembly System"). Two films have been made--one showing the robot sorting out and assembling a toy car, and the other showing the robot sorting a mixed heap of car and ship parts, and then assembling both the car and the ship. 6g

REPORT ON THE SIGART MEETING AT THE NCC
by
Ranan Banerji
Case Western Reserve University
Cleveland, Ohio 7

SIGART met on June 6, during the National Computer conference as announced. This reporter met a number of people the next day who were disappointed to miss it, and said they did not know about it. Perhaps the SIG meetings should have been somewhat better publicized by the NCC Committee itself. Need we punish so severely those members who do not read their newsletters or those sympathizers who are not members? 7a

That's all for the comment. The business part of the meeting consisted mostly of Chairman George Ernst introducing the new chairman, Robert Balzer. There was some discussion of the ACM and SIGART finances. The Chairman answered some questions regarding the mechanism of selection of officers of SIG's under ACM bylaws. 7b

The highlight of the evening was Saul Amarel's talk on present AI activities at Rutgers University. What follows is this reporter's recollection and understanding of what he said. 7c

The three areas of work that he discussed at some length were: 7d

1. A work on automated individualized teaching, where the students' specific shortcomings are analyzed and attended to. As a major example of the analysis of errors, he quoted their work on the guessing of grammar modification. The work differs from those of Solomonoff, Gold, Fu and others in the major respect that the program is not made to guess at grammar about which no information is known except for the example sentence. Instead, it is known that the sentences come from a grammar which is similar in many respects to a given known grammar. Computer-aided teaching of programming has been a major vehicle of this research.

2. A model of a belief system and its use in automatic interpretation of social interactions. This involves explaining motives and goals of people by analysis of how they interact. Such analysis is based on assumptions of a person's belief system about the world, which includes a model of belief systems of other