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TECHNICAL REPORT ARCSL-TR-77004

(EM-TR-77027)

APPLICATION STUDY OF PROGRAMMABLE INDUSTRIAL ROBOTS FOR PRODUCTION LINES AND DEMILITARIZATION PROJECTS

by

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April 1977

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US Army Armament Research and Development Command
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Prepared in cooperation with Stanford Research Institute and Pine Bluff Arsenal

Application study of programmable industrial robots for production lines and demilitarization projects

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Programmable	Unpredictable location
Robot	On-line
Demilitarization	Random orientation
Feasibility	Sensing effector
Hazardous operations	Manipulator

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The purpose of this investigation was to develop and establish the feasibility of employing industrial robots to reliably perform operations of a hazardous nature. The project was divided into three tasks:

Task one was assigned to Stanford Research Institute (SRI) ~~under contract DAAA15-74-C-0095~~. The objective was to develop a system by which a robot, with limited operator assistance, would be able to locate, grasp, and remove objects in an unpredictable location.

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20. ABSTRACT (continued)

Task two was assigned to Pine Bluff Arsenal (PBA). Its objective was to determine the feasibility of using industrial robots to perform on-line functions in a hazardous production environment.

Task three was an in-house project at Edgewood Arsenal (EWA). Its objective was to determine the feasibility of using industrial robots to assemble items made up of explosive or other dangerous components.

The results of all investigations indicated that industrial robots could successfully perform the assigned tasks in hazardous areas.

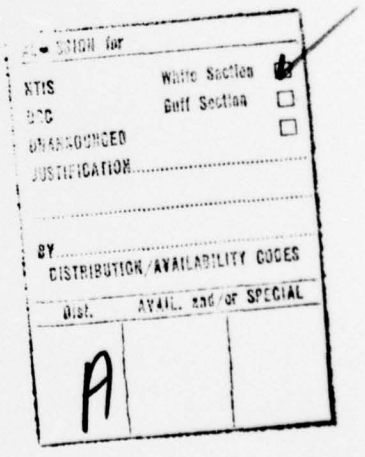
PREFACE

The work described in this report was authorized under Project P4932/5731155, Application Study of Programmable Industrial Robots for Production Lines and Demilitarization Projects. This work was started in September 1972 and completed in January 1975.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Acknowledgment

The author wishes to acknowledge the technical assistance of Messrs. A. J. Sword, Stanford Research Institute, Michael J. McGrew, Pine Bluff Arsenal, and Joseph E. Colonna, Edgewood Arsenal, in the performance of this task.



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APPLICATION STUDY OF PROGRAMMABLE INDUSTRIAL ROBOTS FOR PRODUCTION LINES AND DEMILITARIZATION PROJECTS

I. INTRODUCTION.

Mounting emphasis on safety in the Department of the Army is spurring a trend to automate and remotely control the handling of sensitive and hazardous munitions and munition components.

The application of automated techniques to such operations as explosive packaging, assembly of sensitive components, and demilitarization of obsolete munitions constitute only a few of the many areas in which automation would find a beneficial application.

Requirements for many functions are unique and demand operations which do not readily adapt to simple automated procedures. An extensive search of available "off-the-shelf" equipment disclosed that the industrial robot incorporated most of the unusual capabilities required to successfully perform the complex operations which were envisioned as requirements for many of the proposed activities requiring automation.

The objective of this assignment was to develop the expertise necessary to either preprogram a robot or to direct it, from a safe environment, to perform its required function.

This task is further complicated by the fact that, in one application, the robot is called upon to seek out and retrieve objects in randomly-oriented positions. In this case a simple, position-controlled manipulator cannot carry out the task. Research has shown that touch and force sensing in robots, together with the proper control system, can be used to solve the problems of adaptive control.

II. EXPERIMENTATION.

A. Equipment.

1. Stanford Research Institute (SRI) Project.

The Unimate* system used in the adaptive control study for industrial robots is shown in figure 1. Figure 1 illustrates the laboratory configuration. The operator control station, bottom right of figure 1, is comprised of a VIP-100 word recognizer** and microphone for operator control, a television monitor and display for visual feedback, and a teletype that is used to initialize and start up the system, as well as to provide diagnostic messages. The primary method of control is by voice; the teletype is present solely to facilitate software development.

* Series 2,000 Unimation Inc., Danbury, Connecticut.

** Model VIP-100 Threshold Technology, Cinnaminson, New Jersey.

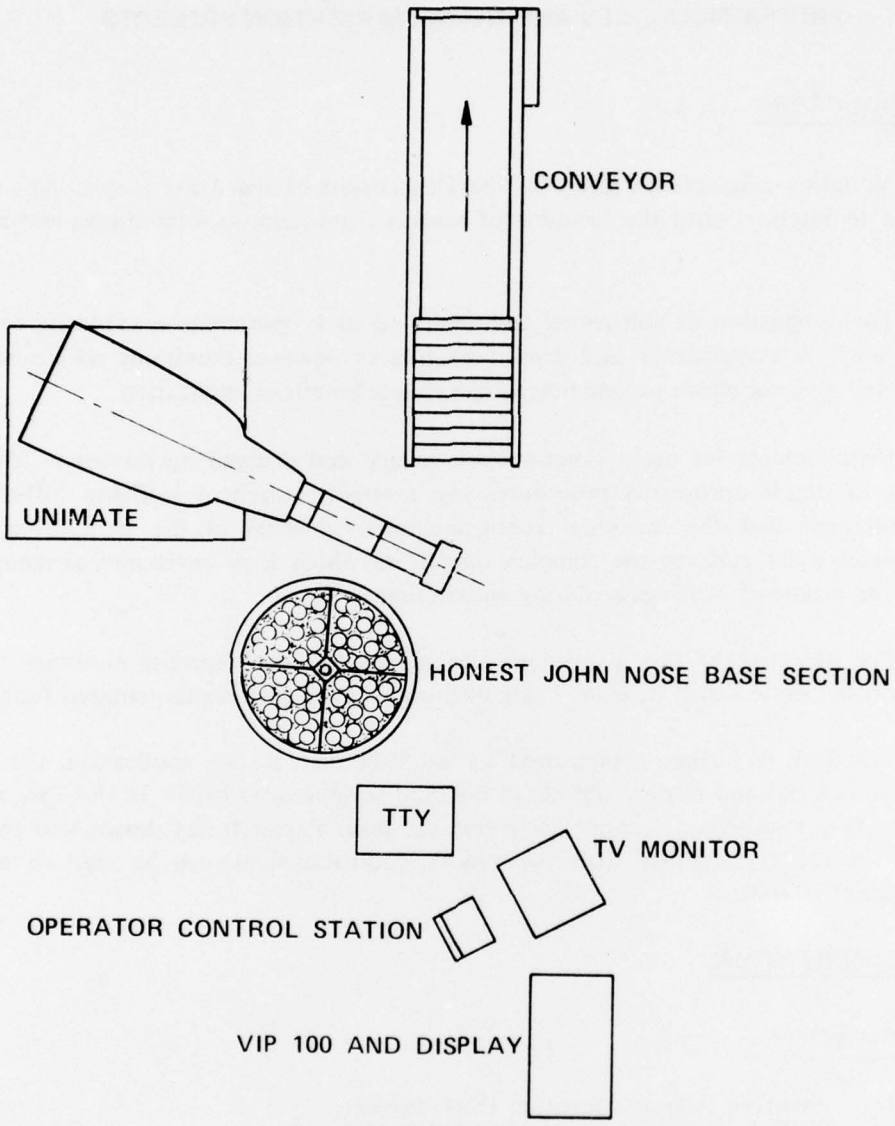

Figure 1. Laboratory Configuration of the Unimate System

The Unimate is equipped with a three-fingered end effector which senses the location of and grabs the bomblet.

2. Pine Bluff Arsenal (PBA) Project.

A Versatran Model E302 Robot (figure 2), manufactured by AMF Thermatool Inc., was used. This point-to-point system consists of four major components: (1) the mechanical unit, (2) the control console, (3) the hydraulic power pack, and (4) the main switch enclosure.

3. Edgewood Arsenal (EWA) Project.

A Versatran Model E302 was also used in this project. Additional equipment included a variable-speed turntable, an air-operated clutch, and a mechanical hand. Figure 2 provides a functional illustration of the system.

B. Investigational Procedures and Results.

1. Stanford Research Institute (SRI) Project.

This investigation is concerned with the development of a system which, with limited operator assistance, is able to locate, grasp, and remove objects in an unpredictable location. In order to test the feasibility of the concept, a 760-mm Honest John nose section filled with 76-M139 bomblet submunitions was used.

The manipulator is normally directed by voice command utilizing the VIP-100 word recognizer. This unit recognizes individual words or phrases and is programmed for a 32-word vocabulary. The robot's search and grab system is initiated by teletype. The operator views the nose cone by means of a closed-circuit television (TV). A centering reticle is superimposed upon the viewing screen of the TV.

The operator talks the manipulator into position directly above the bomblet selected for removal. When the operator has a bomblet centered on the reticle of his TV monitor, he issues the action command "GRAB-IT." This terminates the manual-control phase of the bomblet-removal process and initiates the automatic phase.

In the automatic phase, the PDP-10 command computer performs a sequence of five different activities without operator assistance, as listed below:

a. It locates the designated bomblet (determines its world coordinates).

b. It determines the subvolume of the missile nose base in which the designated bomblet lies.

c. It places the grasping device in the proper orientation to remove a bomblet from that subvolume.

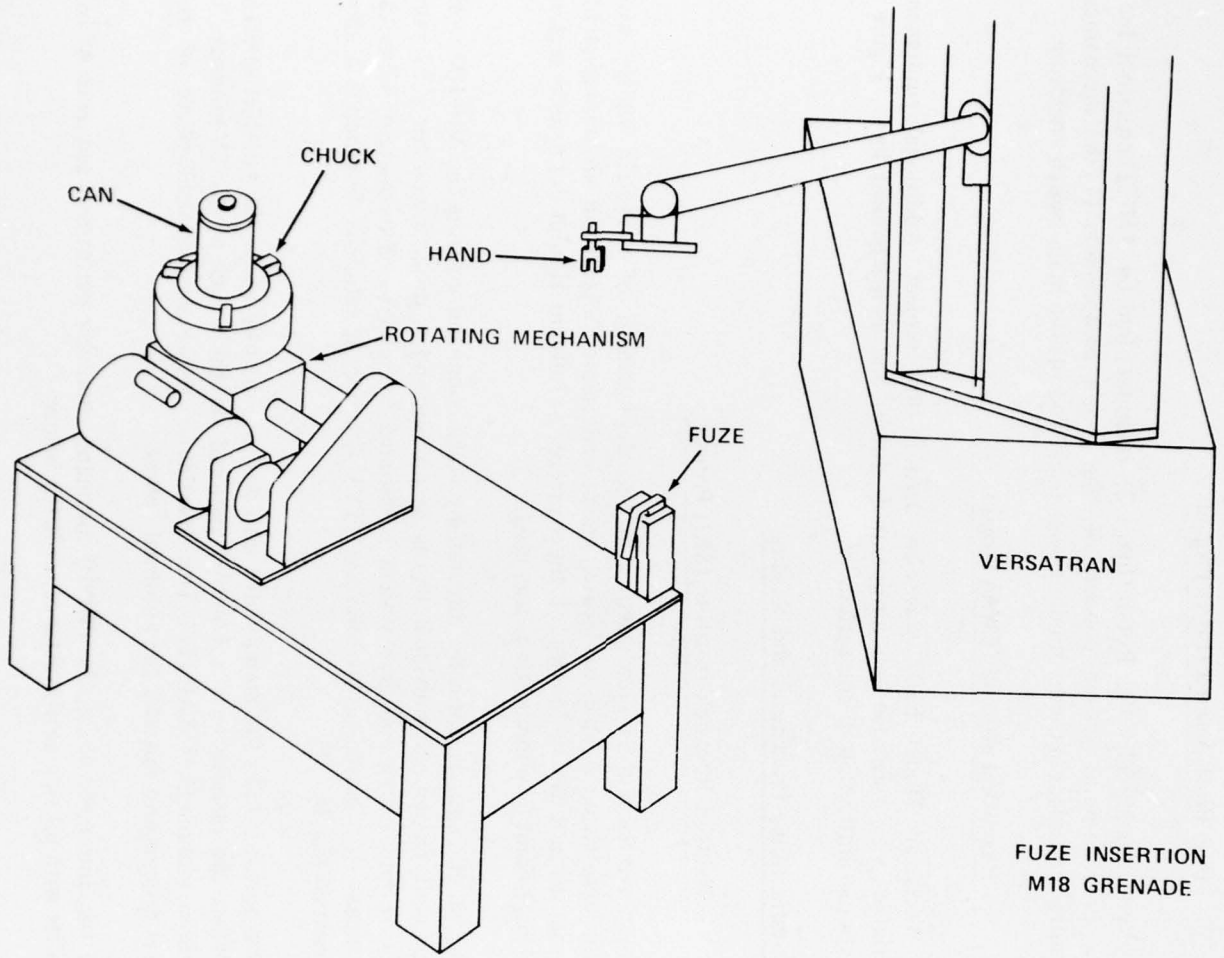

Figure 2. Versatran Model E302 Robot

d. It places the fingers of the device around the designated bomblet, guiding it by touch.

e. It grasps the bomblet, removes it from the nose base, and carries it to the conveyor belt.

The function, FINDBOMBPOS, which executes in the PDP-10 computer performs the activities in the five steps (a through e) listed above. A flow chart (figure 3) shows some of these steps (a series of substeps) in more detail. The key step in the success of the automated phase is step d, during which phase the Unimate is adaptively controlled, based on sensory information.

Feasibility and reliability of this system were satisfactorily demonstrated for the Versatran. Specific applications considered included white phosphorus load and pack line, M18 grenade line, XM47 filling line, and white phosphorus filling line.

2. Pine Bluff Arsenal (PBA) Project.

This investigation is concerned with the adaption of industrial robots to function in a hazardous production environment. A number of specific applications, which would lend themselves to actual installation on a production line, were reviewed.

The white phosphorus load and pack-plant application of loading wooden packout boxes with two 105-mm M60 munitions was selected as a specific task to attempt for actual production-line demonstration.

The Versatran was programmed and verified. The cycle time of the robot proved to be less than the required production rate, and attempts to increase the cycle were to no avail. This fact precluded the planned use of the Versatran on the production line.

The robot was employed in a simulated production-line installation which was comparable with the limitations of the equipment.

3. Edgewood Arsenal (EWA) Project.

The investigation is concerned with the adaption of an industrial robot to perform tasks of a hazardous nature. The application chosen called for the insertion of the M201A1 fuse into the M18 grenade.

The Versatran was programmed to travel to the point at which the fuse was located. The robot arm then descended and engaged the fuse. The fuse was held in place by the magnet while the robot moved it to a position over the can. The arm again descended, locating the fuse in the threaded collar on the can. Spring pressure was exerted by the hand; the can-rotated fuse was threaded into the canister. The operation presented no problems. An adjustable torquing device was not available; however, the hand could be mounted on such a device and the fuse torqued to a predetermined limit.

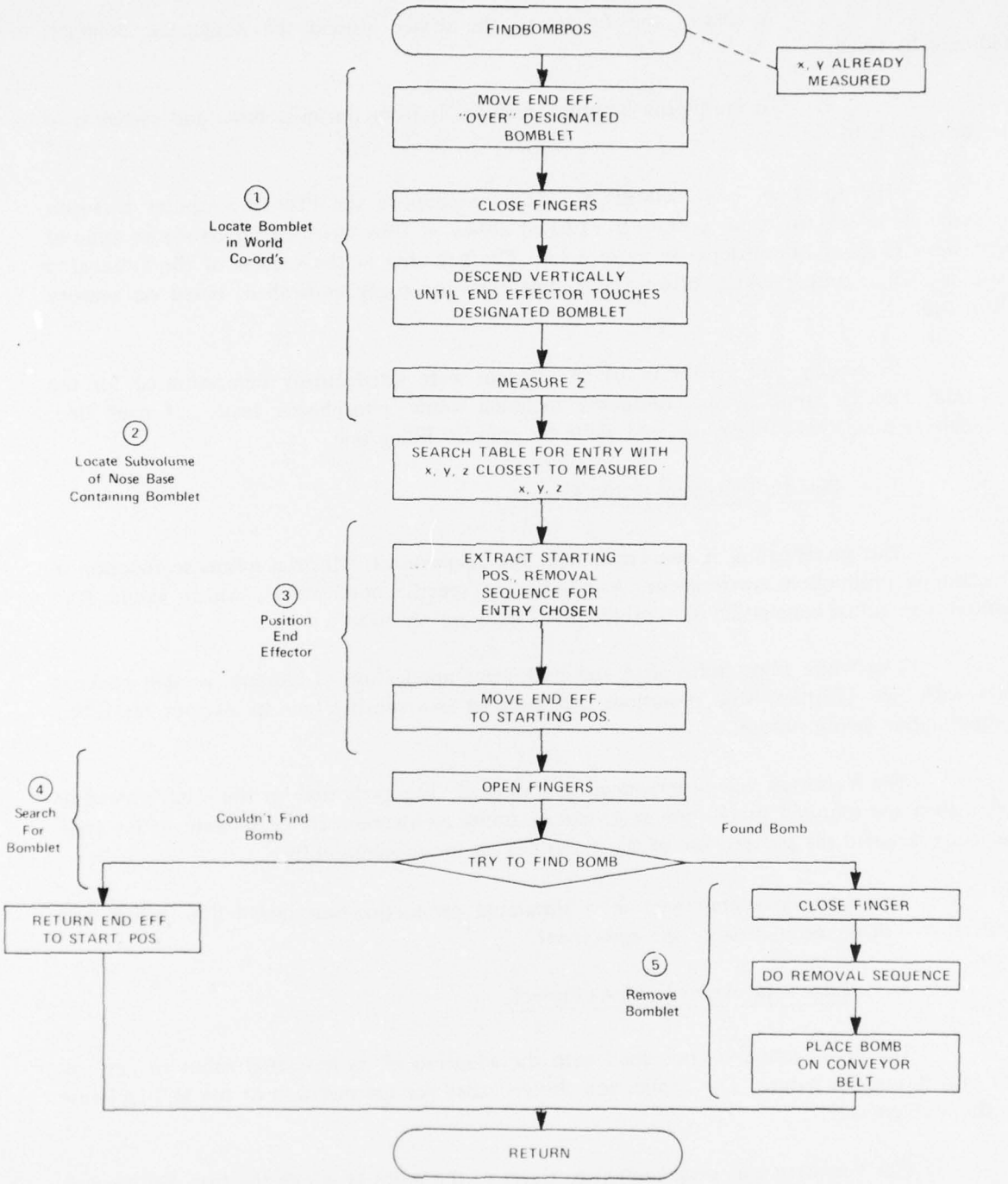

Figure 3. Flow Chart – FUNCTION FINDBOMBPOS

III. CONCLUSION.

Based upon the results of this study it is concluded that the purpose of this investigation has been fulfilled. The feasibility of employing robots, or robot-oriented systems, to reliably perform operations of a hazardous nature has been established.

IV. RECOMMENDATIONS.

It is recommended that industrial robots be given serious consideration in future modernization plans for existing facilities and in the planning of new ones. Of immediate concern are the smoke, pyrotechnic, and pilot facilities currently being planned for Picatinny, Pine Bluff, and Edgewood Arsenals.

Among factors, other than safety, which are deserving of consideration in assessing the value of robot applications are operator fatigue, monotony, environmental factors, reliability, cost, etc.

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