A prototype of a robotic arm for handling of TLD badges is developed.

A Robotic Manipulator for Handling TLD Badges

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Abstract: *A prototype system for automatic handling of Harshaw/Bicron (now ThermoFisher Scientific) thermoluminescent dosimetry (TLD) badges, which is based on a robotic arm, was designed and built. The robot performs the loading and unloading of the TLD cards in the badges and transports them between the loading/unloading station and magazine stations. For quality assurance, a sticker containing the worker's details printed in barcode format was added to the badge. Automatic on-line identification is performed for checking the correlation between the badge and the TLD card number. Health Phys. 95(Supplement 5):S190–S193; 2008*

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INTRODUCTION

Badges containing thermoluminescent dosimeters (TLD cards) are supplied to radiation workers to provide information needed for estimating the external exposure. They are returned to the dosimetry laboratory on a regular basis (mostly after a period of 1 mo) for dose evaluation by reading the TLD crystals by a TLD reader. Each TLD card has a unique number which is correlated to a specific worker in a database, to whom the evaluated dose is attributed. Loading and unloading TLD cards to their badges is one of the tedious and time-consuming tasks that every TLD laboratory has to deal with. No product is currently available with an automated process for card extraction and handling. In this work a prototype system, which is based on a robotic manipulator, was designed and built. The robotic system loads and unloads TLD cards to the badges, and loads/unloads the cards to a magazine for the TLD reader.

At the Nuclear Research Center Negev (NRCN), each badge is assigned to a specific worker and bears a sticker containing the worker's personal details, also in a machine-readable format (barcode). This is done for quick identification, and also to identify possible contamination of the badge by constant elevated readout of a specific TLD card. The procedure of assigning specific badges to workers is different from that employed in most dosimetry laboratories, and keeping the order of the TLD cards and the badges in their magazines becomes extremely important. It is crucial that a strict quality assurance (QA) procedure will ensure an error-free match between the TLD card and its corresponding housing. Therefore, the robotic system includes a barcode reader station where the TLD card number mounted in the badge and the worker's details (as they appear on the badge sticker) are read and compared. The system prototype was successfully tested for several hundreds of cycles.

THE TLD CARDS BADGE

The dosimetry laboratory at the NRCN operates an automatic TLD cards reader model 6600 of Bicron/Harshaw (now ThermoFisher Scientific, 81 Wyman Street, Waltham, MA 02454, USA), controlled by a computer. Most of the TLD cards in use for routine personal dosimetry are Bicron/Harshaw TLD-100 (LiF:Mg, Ti) cards containing three 3 mm × 3 mm × 0.38 mm chips (LG7776 cards). At the location of chip 4, only Teflon is present.

The TLD cards are placed in badges manufactured by Bicron/Harshaw (type 8855), equipped with a carrying strip. On the back of the badge there is a transparent window which enables the reading of the barcode of the TLD card inside the badge. At NRCN, the badges are personal, each belonging to a specific worker. In order to help the identification and prevent mistakes, on the front side of the badge a sticker is added, which contains the employee's picture,

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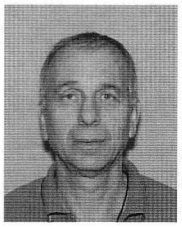

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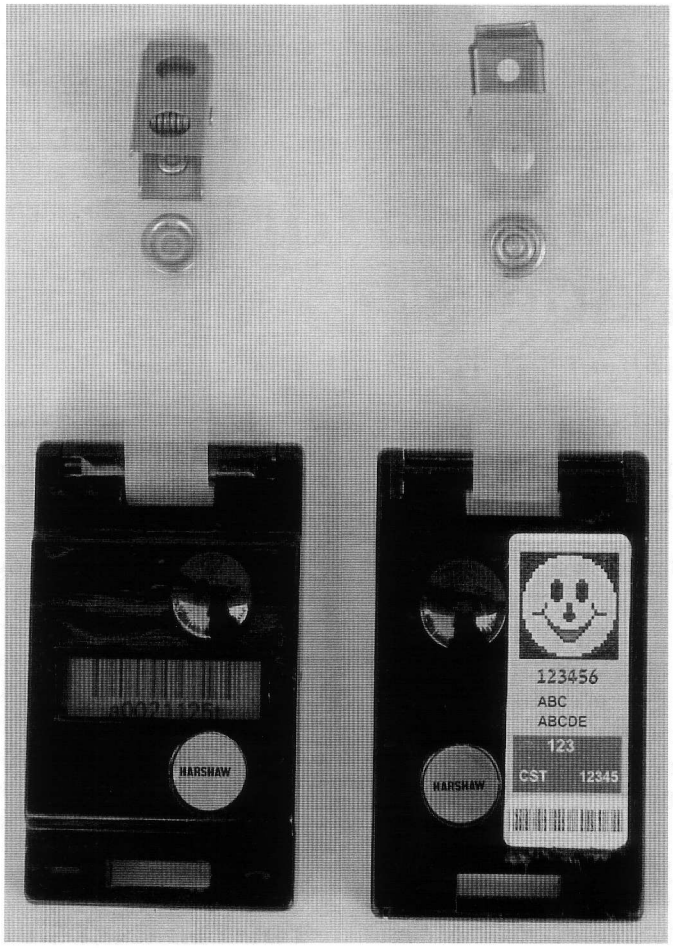

Figure 1. The TLD badge.

his/her personal identification (ID) number and name and workplace affiliation. The badge type (whole body, extremity, etc.) and the TLD card number are added as well. At the bottom of the sticker there is a barcode containing all this data. The use of a barcode enables automatic identification of the badges and the TLD cards, by instant access to an appropriate database. The badge, seen from the front and the back sides, is presented in Fig. 1.

THE ROBOTIC SYSTEM

In principle, automation of loading and unloading the TLD cards to their badges can be done by flexible or inflexible automation. Inflexible automation means developing a machine that is designed to perform only specific, well defined functions. Developing such a machine requires a professional staff, and changes or upgrading of such a system is complicated, expensive, and sometimes even impossible. A flexible design means using a general purpose machine (robot) which can be programmed to perform a sequence of defined functions. Development and improving is much easier, and changes can be performed mostly by simple programming. The main drawback may be the higher cost of a robotic system.

The opening of the TLD badge is usually done by a manual tool, supplied by Bicron/Harshaw. The automatic system that was developed simulates this operation, adding transport functions between fixed stations. Robotic automation was chosen due to the complexity of the tasks needed and the possibilities of future changes and developments of the system. The development was based on a robotic arm, which is a commercially proven product that can be chosen to fit various needs. Robotics enables the closest simulation of the human action when handling the TLD badges. Changes and improvements can be made on the same system without the need to change components. The investment in a robot is not lost because if a system is not needed anymore the robot can be used for other purposes.

The development was performed at the Robotics Laboratory of the Mechanical Engineering Department at Ben-Gurion University by using a Mitsubishi industrial robotic arm with 5 degrees of freedom, model RV-E5NJ (Mitsubishi, Denki Building 2-2-3, Marunouchi, Chiyoda-ku, Tokyo, Japan). The robot is a serial device, as each component transmits movement to the next component. The number of components determines the degrees of freedom. It is a common type of robot, having the ability to combine linear and circular movement. Pneumatic and electric subsystems were added for opening and closing the badge and loading/unloading the TLD card.

The robotic arm is equipped with a gripper, which includes custom made fingers and a vacuum nose. The function of the fingers is to seize the badge and bring it to a certain location. The fingers are coated with a rubber sheet and are designed to apply a pre-designed pressure. The position repeatability is ± 0.03 mm. The velocity is in the range 0.2 mm s^{-1} to 650 mm s^{-1}, the distance range is up to 630 mm, and the angle range is up to 320°.

THE OPERATION OF THE ROBOTIC SYSTEM

The operations of the robot are programmed in the "Movemaster"

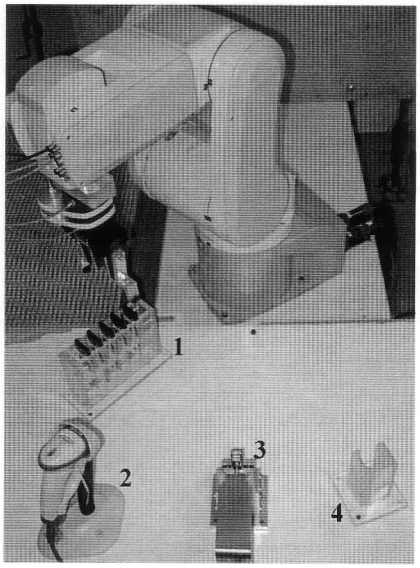

Figure 2. The robotic system. The numbers indicate the workstations.

programming language (Mitsubishi). The program was developed interactively by using the reverse kinetic method. At this stage of developing the program, the operations were simulated in a virtual space and displayed on a screen. The program contains sequences of orders including steps from point to point, combined with auxiliary tasks. For the actual system, 67 points are used in a 2,450-line program.

A Mitsubishi CR-E356 controller was used. It controls the movements of the arm components through servo-motors, stores the coded orders for operation of the robot and controls the input and output information to the auxiliary systems (vacuum pump and electric sub-systems). Data can be transmitted conveniently to the program through a Labview interface (National Instruments Corp., 11500 N. Mopac Expressway, Austin, TX 78759-3504, USA).

The robot was designed to operate between the following fixed stations (see Fig. 2):

1. The badges cassette, in which the closed badges are stored. The badges are placed with their strip and clipper downside to avoid disturbing the mechanical movement;
2. The barcode reader, which scans the barcodes on the badge and on the TLD card. For quality control, the barcodes of the TLD card and the badge are compared to verify that they match. A database application is used to track the badges and TLD cards individually;
3. The load/unload station. For opening the badge and unloading the TLD card from it, the badge is mounted on a special base. The badge is opened by a pneumatic holder-opener. The robotic arm uses its gripper finger to open the badge. Then the vacuum nose is used to carry the TLD card out of its badge. The badge is then closed, and moved back to the badges cassette. Loading the cards into the badges is performed at the same station in reverse order; and
4. A card holder into which the TLD cards are placed is the last workstation. It simulates the magazine used for reading the cards in the Harshaw 6600 reader.

LOADING AND UNLOADING THE CARDS INTO THE BADGE

The most complicated operation is to open the badge and to take the TLD card out to the readout magazine (or install the card back in the badge), which is performed at the load/unload station (station 3). For unloading, the badge is brought to the station after being taken out from the badge magazine (station 1), and passing the barcode reader (station 2). The badge is put into the opening position (see Fig. 3) after sliding it over the metal area, to avoid disturbance by the plastic strip. The rubber tip completely opens the lid of the badge, and the vacuum nose holds the card and brings it to the cards magazine (station 4). The empty badge is closed and moved back to its original position in the badge magazine. For loading the cards into the badges, the operations are performed in reverse order. The robot gripper with its components is seen in detail in Fig. 3 at the load/unload station (station 3). The operation is

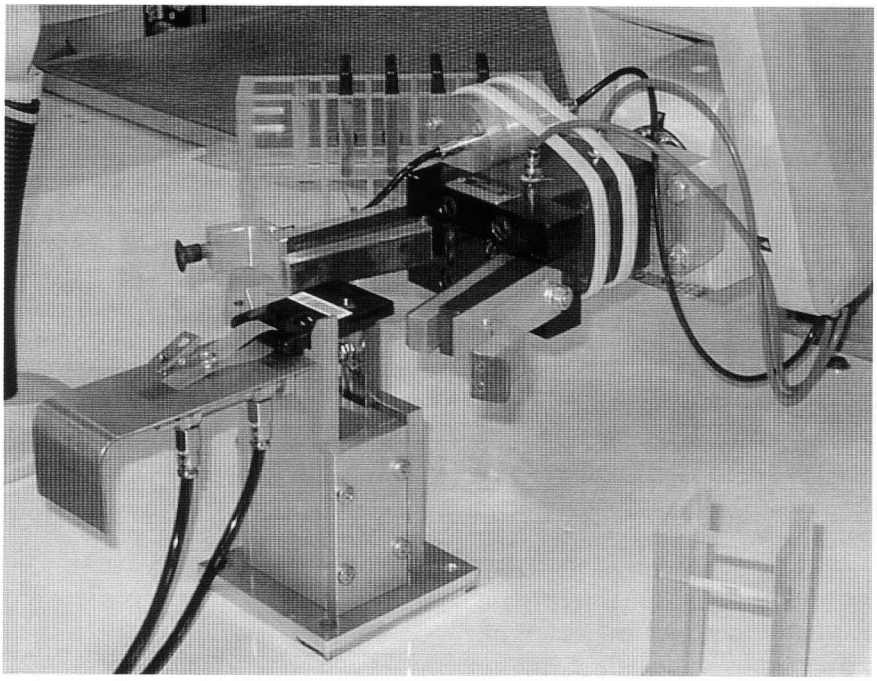

Figure 3. Gripper parts and the load/unload station (station 3).

sequential; the order of the badges and the TLD cards in their magazines remains unchanged.

SUMMARY

A prototype of a robot system for handling of Harshaw/Bicron TLD badges was designed, built, and tested. It demonstrated a full operational capability in laboratory tests. The system was tested by unloading and loading several hundreds of badges. In the prototype system the speed of the robotic arm is limited, as an available older and slower robot was used; therefore the prototype was not operated beyond the testing phase. The average time for the load/unload cycle in the present system is about 60 s, but an optimized industrial system with a cycle time of 6 to 10 s per badge is feasible. Further optimization may include two barcode readers (for simultaneous card and badge reading), a more modern robotic arm, and a more rigid and stable basis plate for supporting the system.