Universitat de Girona
Escola Politècnica Superior

MAIA

LAB REPORT

IRRADIATION OF SPECIFIC ZONES IN THE BODY

Computed Aided Surgery and Medical Robotics

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Date: 23/12/2021

1. Project Definition

Problem statement: Radiation therapy is used as a treatment measure in more than half of all patients with cancer, in which high doses of radiation are used to damage malignant cells leading to their death or slowdown in growth.
However, Radiation therapy does not kill cancer cells the first time and the process takes time over multiple sessions. Furthermore, it can have negative effects on the patient's healthy cells if the beams are not precise.

Therefore, using a robot for fixing the exact location of the irradiation can make the irradiation process smoother with minimal damage to healthy tissues in the irradiated area.

Purpose: Our main purpose is to design an algorithm based on the Staubli robotic arm to help the doctor make the irradiation more accurate, simple and minimize additional risks to the patient's health.

Plan: Irradiation of a tumor in the brain, from 5 different user-defined points of view (1-5) with an option for the user to choose the time (in seconds) for each radiation point. The robot we are using is the TX60 Staubli robot.

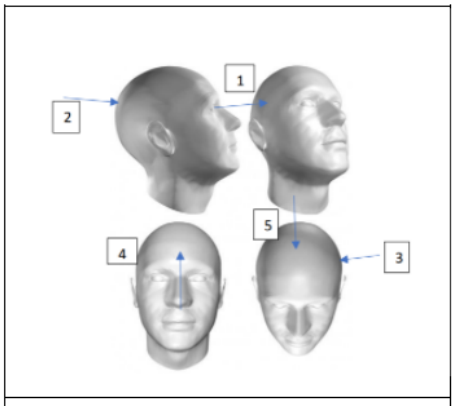

Figure 1 -Planned irradiation points

Figure 2 - CyberKnife

The inspiration for this project to design such an irradiation system stems from CyberKnife, a commercial robotic radiosurgery system designed to treat cancer. It is used to precisely and accurately focus the high dosage of radiation beams in the brain and body. With robotic technology, this treatment device rotates around the patient, and is able to carry out the treatment by irradiating from hundreds of different angles.

In our project, there are a maximum of 5 points that the user can select along with the amount of time each spot is exposed to radiation. The robot should then move to each of these positions with a specified wait time. The last step is to return the robot to the home position and the irradiation process stops.

2. Tool definition

The Tool definition was performed manually. A 30cm needle was selected as a mock-up for the irradiation device and placed in the end effector hold of the TX-60 arm. 4 points were then taught centering on a pencil tip. From these 3 of the 4 points, the center of the sphere was calculated and subtracted with the final point to get the new tool displacement as follows.

Tool_name	X	Y	Z	RX	RY	RZ
Tool_1	-30	-30	480	-180	0	-180

Table 1- Tool definition coordinates

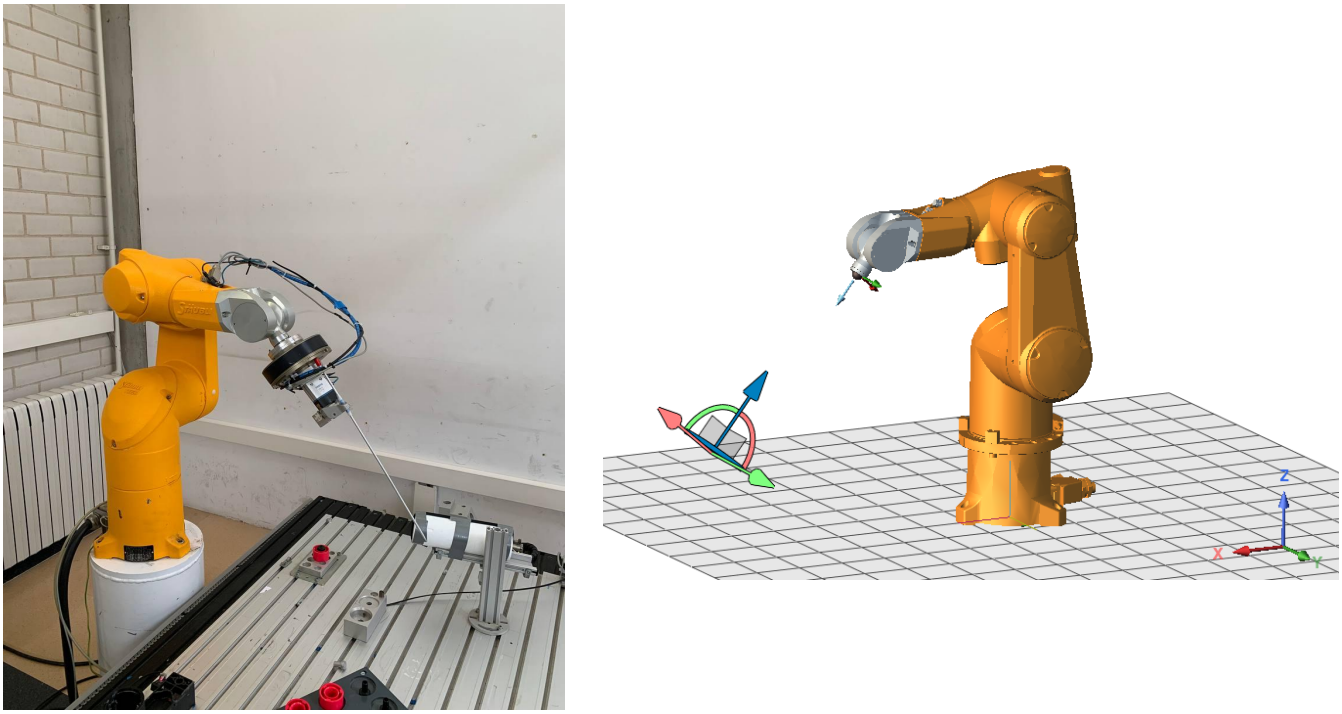

Figure 2: Robotic arm in tangible (left) and simulation (right) showing the defined tool along with its axes.

3. Frame definition

As the main goal of the project is the irradiation of specified spots in the head, the frame was defined as just a singular point relatively at the center of the spherical ball fixed on the bench. The frame definition was obtained by centering the tool at the sphere as shown in the figure below.

Frame_name	X	Y	Z	RX	RY	RZ
radiation_point	417	0	-340	0	0	0

Table 2 -Radiation points

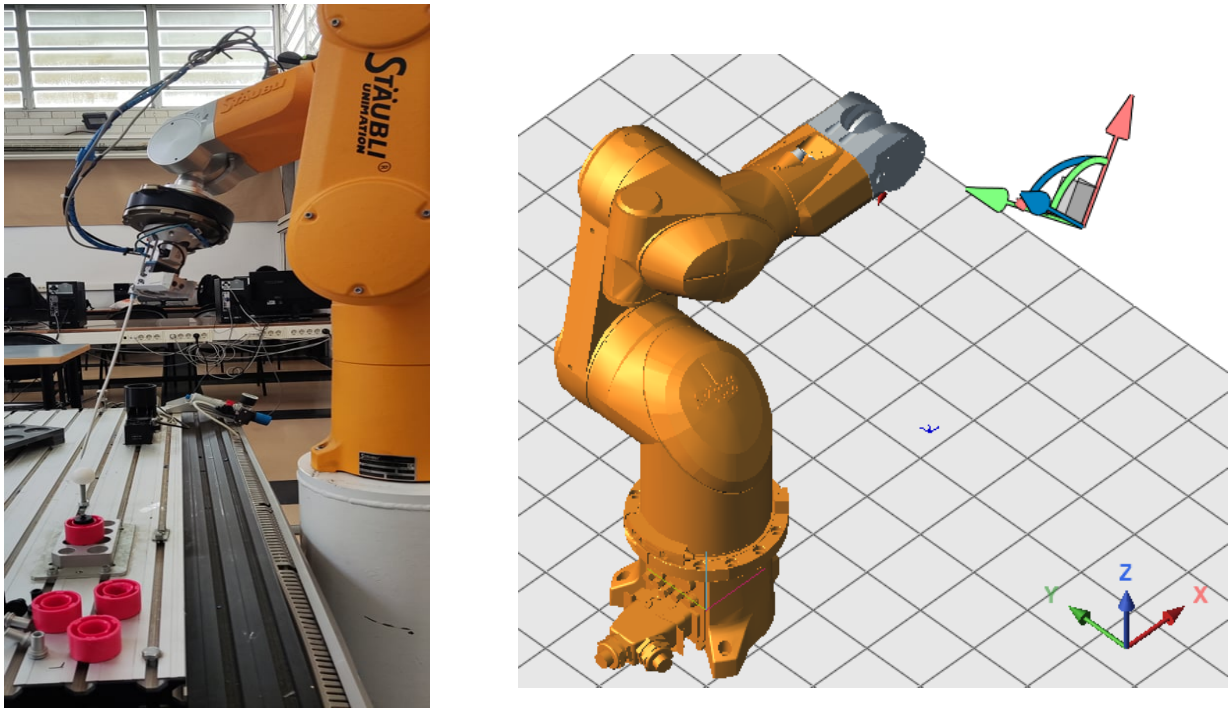

Figure 3: Robotic arm in tangible (left) and simulation (right) showing the defined frame along with its axes.

4. List of Variables and points

Variable	Type	Description
home	Joint	Home position
mNomSpeed	mdesc	Robot arm speed
i	num	For loop variable
nKey	num	Variable to check the user input key
npoints	num	Number of points to be irradiated (User defined)
num_ord1	num	Variable to repeat the program
nWait_time	num	Number of wait time in seconds at each point (User defined)
rad1[5]	Point	Approximation points for frame 1 to 5

Table 3- List of variables used in the code including their description and type.

5. Simulation in Staubli Robotics Suite

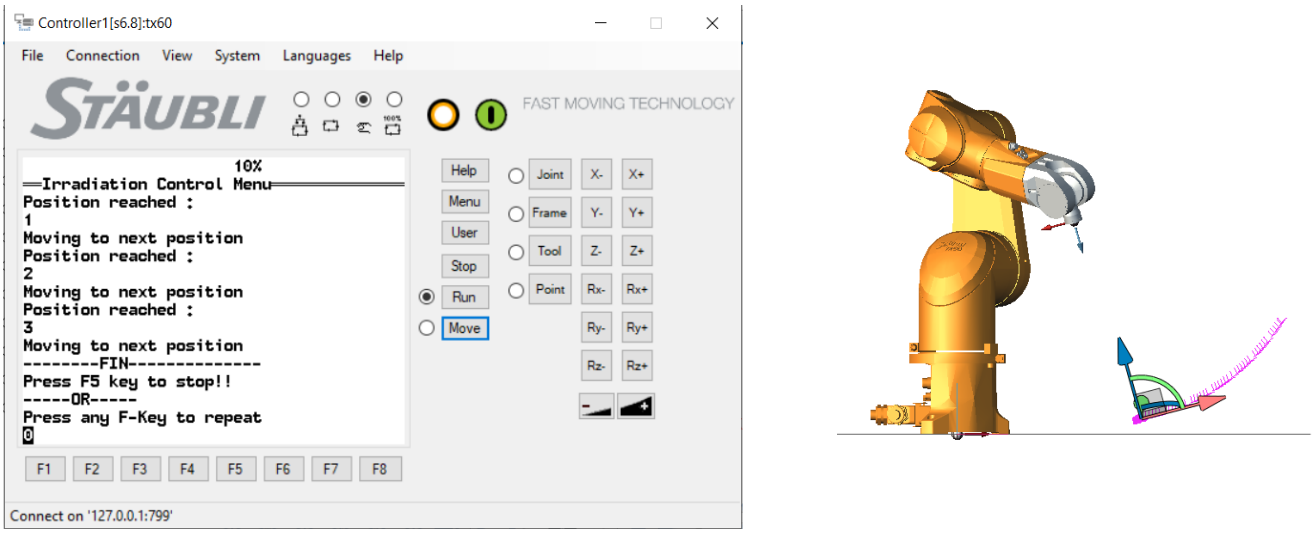

Figure 4: Controller display (Left) and 3D simulation of the robotic arm (Right) during program execution visualized in Staubli Robotics Suite.

6. Block Diagram

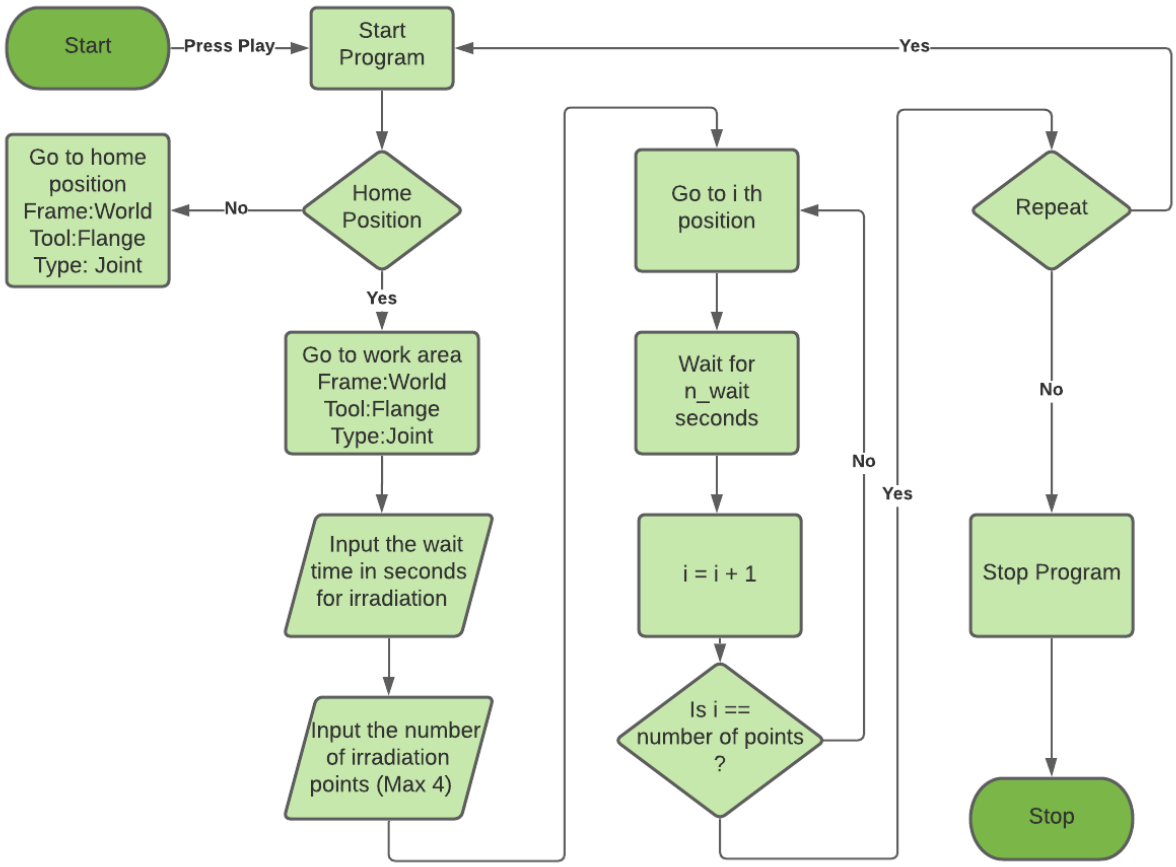

Figure 5: Block-diagram showing the complete algorithm followed by the program

7. Code

```
begin
  userPage()
  cls()

  title("Irradiation Control Menu")

  num_ord1 = 0

  //While used to stop the program if
  while num_ord1 != 275
```

```
    //Ask to enter the wait time
    putln("Enter the wait time on each radiation point (Choose a number) :
")
    nWait_time = 0
    nKey = 0
    // Waits for Return to be pressed to confirm
    do
      nKey = get(nWait_time)
    until(nKey == 270)

    //Ask to enter the number of points to irradiate
    putln("Enter the number of radiation points : [1-5]")
    npoints = 0
    nKey = 0
    // Waits for Return to be pressed to confirm
    do
      nKey = get(npoints)
    until(nKey == 270)


    mNomSpeed.vel=25       // Speed variable
    putln("Initializing everything")
    enablePower()

    //Move to Home position
    putln("Moving to Home position")
    movej(home[0], radiation_devic[0], mNomSpeed)
    waitEndMove()
    putln("Home position Reached")
    delay(2)


    //Move code block that loops over the positions
    for i = 0 to npoints - 1    // as it starts from 0
      movej (rad1[i] ,radiation_devic[0] , mNomSpeed)
      waitEndMove()
      putln("Position reached : " )
      putln(i+1)
      delay(nWait_time)
      putln("Moving to next position")
    endFor
```

```
    putln("--------FIN--------------")
    putln("Press F5 key to stop!!")
    putln("-----OR-----")
    putln("Press any F-Key to repeat")
    num_ord1 = get(num_ord1)        // Get input from user

  endWhile

end
```

8. Conclusions

Computer Aided Surgery and robotics has proven itself as the go-to today and with further improvements in technology will soon be a mainstream method of surgery, if not already, because of its accuracy, precision and time-effectiveness.

In this project, we were able to build a simple yet complete algorithm that performs irradiation on the head of a patient with user-defined points and wait time. The robot used was the Staubli TX60 and inspired from real-life commercial robotic systems as CyberKnife is more precise, has higher accuracy and is more flexible than industrial robots. During the course of the project, we gained valuable experience working with an industrial robotic arm for a surgical purpose. We worked with VAL3 programming language and Staubli Robotics Suite.

References

1. Staubli TX60 Robot Manual
2. Val3 Reference Manual, Staubli Faverges, Version 53, D28062804A, -02/2006.