a Fast-Learning and Observant Robot for Empowering and Nursing in Containment Environments (FLORENCE)

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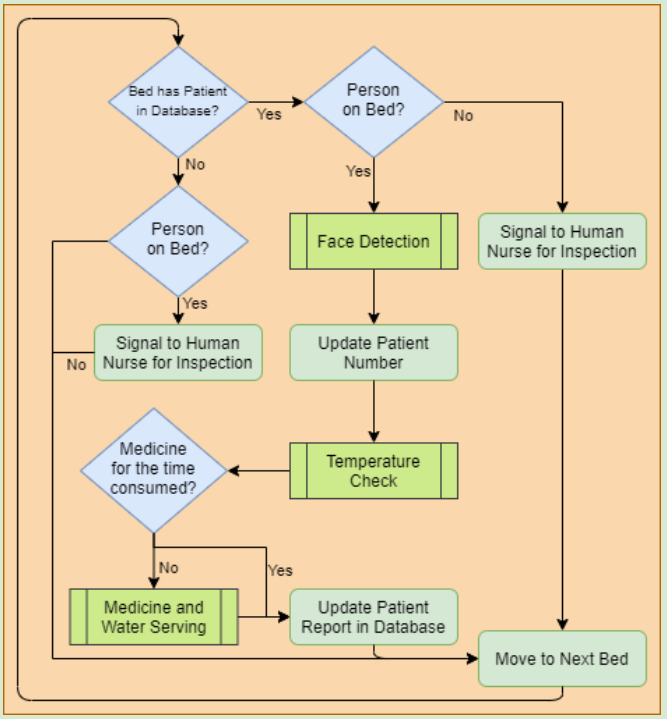
Problem Statement

In the light of the present pandemic, it has become a key necessity to control the spread and decrease the impact of the virus in the greatest manner possible. We present an intelligent nurse, FLORENCE, who, in a containment facility, detects the face of each patient and administers the patient's unique set of medicines from a separate trolley based on a predetermined database. She further checks the patient's temperature and updates the information in the database. This prevents the need for a human nurse to approach the patient and hence reduces the risk of spreading the disease. On detection or by request, FLORENCE sprays sanitizer on the hands of patients and visitors. For the purpose of serving the patient, she also uses a hybrid of the original hand and a specially designed hand with three fingers. We intend to perform the simulations on the WeBots platform prior to the implementation of FLORENCE on the TIAGo++ robot by PAL Robotics.

System Flowchart

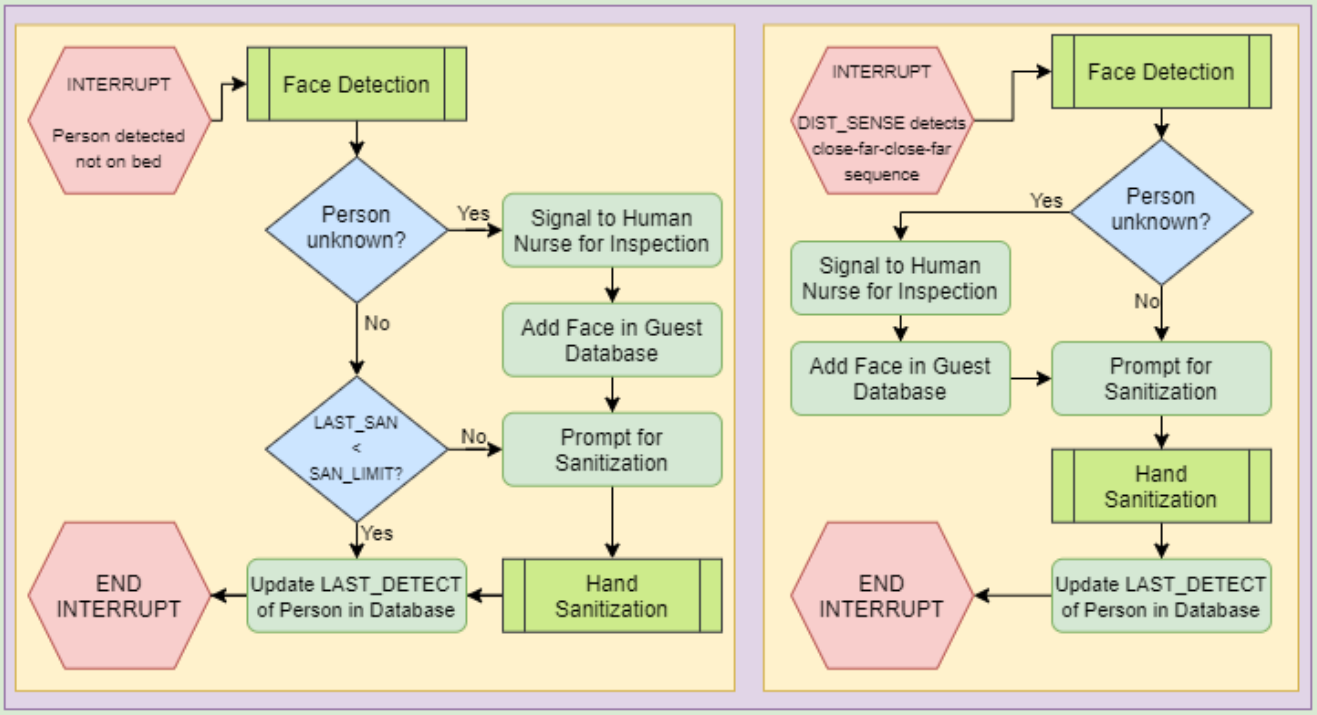


FLORENCE is an automated robotic nurse who is capable of providing several amenities to visitors and patients in a containment facility. As a result of her multifaceted nature, her design is heavily modular. The main functionality of FLORENCE is controlled by the MAIN loop whereas two INTERRUPTS may break the loop at any instant the trigger (mentioned in the interrupt block) is provided.

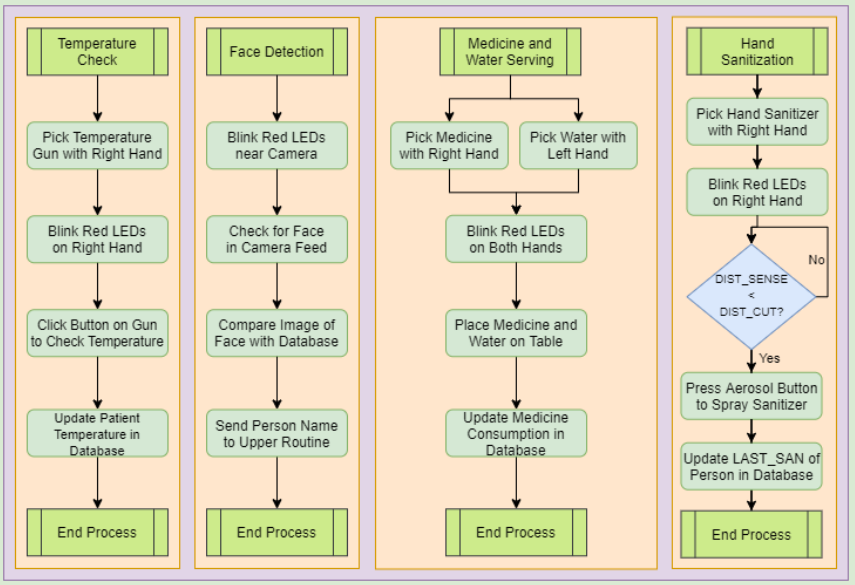
On a regular basis, FLORENCE attends the beds in the room one after the other. At each bed, she searches for the presence of a patient corresponding to the bed.

- If there is an unknown person on the bed despite there being no entry for the same in the database, FLORENCE alerts a human nurse for inspection.
- If a patient is detected on a non-empty bed, FLORENCE detects their face and updates the patient number. Furthermore, she checks the temperature of the patient and serves medicine

if the patient has not had their dose for that time of the day. Finally, she updates the patient's report in the database and moves to the next bed.



The ***first interrupt*** occurs when a person not lying on a bed is detected such as someone who is walking or standing in the room. FLORENCE detects the person's face and informs the human nurse if the person is not present in the database. Following this, she performs a check in the database if the person was last sanitized within SAN_LIMIT time. If not, she prompts the person for sanitization visually (LEDs) and aurally (beeps from a buzzer) following which she sanitizes the person's hands. The ***second interrupt*** is activated when the distance sensor on the right hand detects a sequence of low-high-low-high (close-far-close-far) representing the hand of a person signaling for sanitization. FLORENCE detects the person's face and prompts for sanitization. On sanitization, she updates the LAST_DETECT parameter of the person in the database. Both interrupts involve an update of the person's latest detection in the database. This helps in maintaining the visitor entries on the database since these temporary entries need to be removed in a fixed amount of time after the LAST_DETECT time of the visitor.



The MAIN loop and the interrupts occasionally reach subroutines that represent a sequence of internal events.

- The ***Temperature Check*** subroutine picks the temperature gun with the 3-fingered right hand and signals for checking temperature, following which FLORENCE clicks the button on the gun and, on checking the patient's temperature, updates the value into the database.
- The ***Face Detection*** subroutine signals to the person to look at the camera following which it performs a search for faces and a comparison of detected faces with the database to obtain the name of the person it had detected.

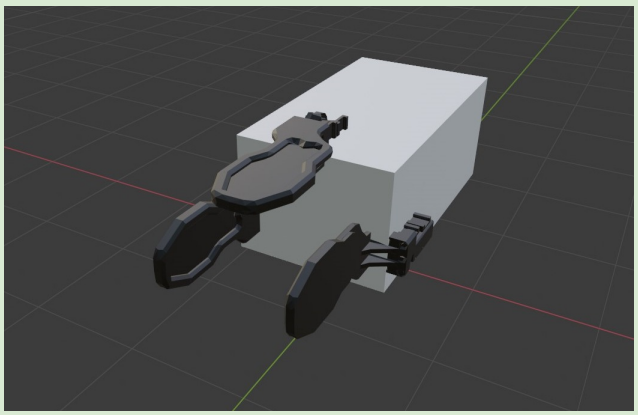
- In the ***Medicine and Water Serving*** subroutine, FLORENCE picks medicine with her right hand and water with her left hand, signals to the patient, places the medicine on the patient's table, and updates the database once both have been accepted by the patient.
- FLORENCE, as part of the ***Hand Sanitization*** subroutine, picks the sanitizer bottle with her right hand and signals to the person. Following this, she presses the aerosol button once the distance sensor detects that the person's hand is near. The LAST_SANitized timestamp of the person is updated in the database.

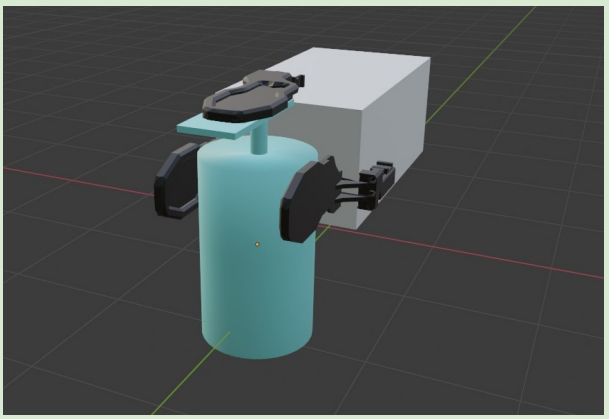
Simulations and Outputs

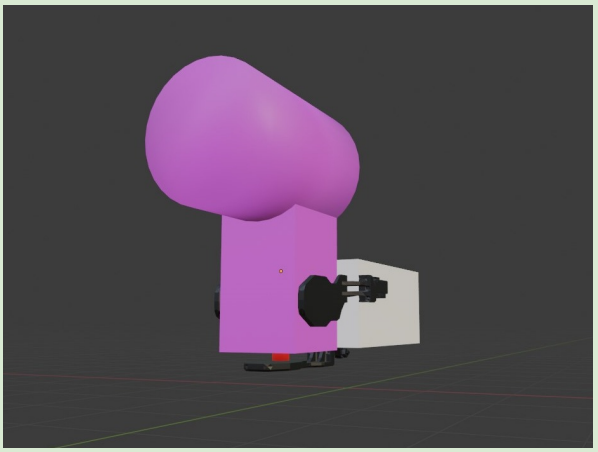
We have performed the robot simulations on the Webots platform to demonstrate the working of FLORENCE. On the other hand, we have performed tests of the face recognition algorithm on Python using the Google Colabs platform. At the same time, we present a demonstration of the working of the database that contains a list of patients and visitors along with data points that represent the last time of detection, whether the patient's medicine has been served, and other critical functionalities. We intend to merge these three processes for the TIAGo++ robot at the finals of the hackathon. We have made the code and the related files public and open-sourced via a common GitHub repository. Our combined simulation video is also available on YouTube.

The Three-Fingered Hand

We intend to utilize a three-fingered hand due to the requirement of the hand to click buttons on the objects it is grabbing. For example, in order to spray sanitizer, the hand needs to press the aerosol button of the sanitizer. In a similar way, the hand needs to press the button of the temperature gun to measure the temperature of the patient. These functions require an extra finger as we have suggested below. Using a five-fingered hand is not required and will lead to overactuation.



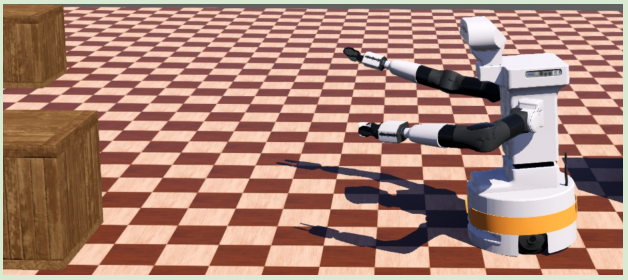




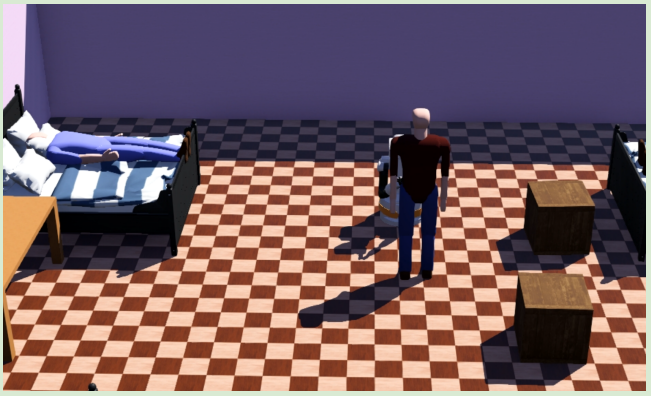
Robot Simulation

The Containment Environment (Video Clip)

Serving Medicines and Water (Video Clip)

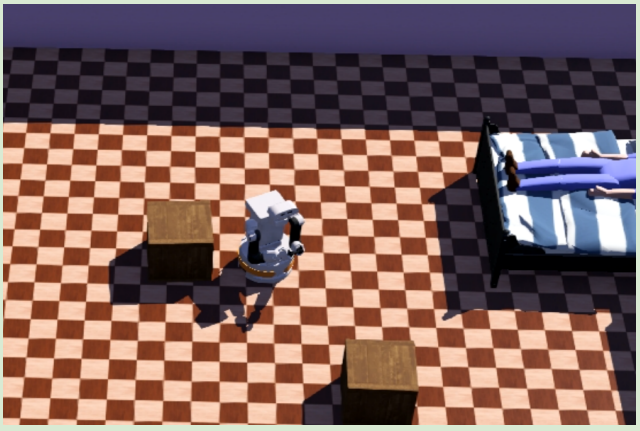


Sanitizing a New Visitor (Video Clip)



Avoiding a Sanitized Visitor (Video Clip)

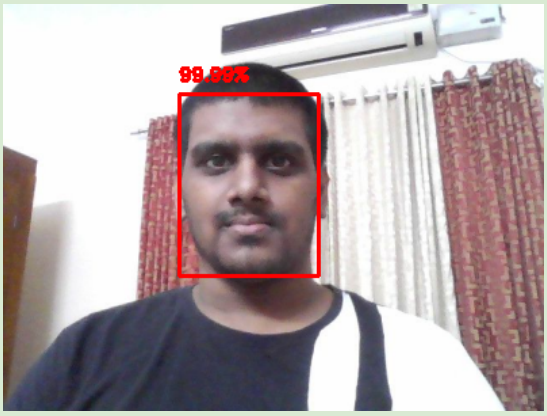
Avoiding Obstacles (Video Clip)



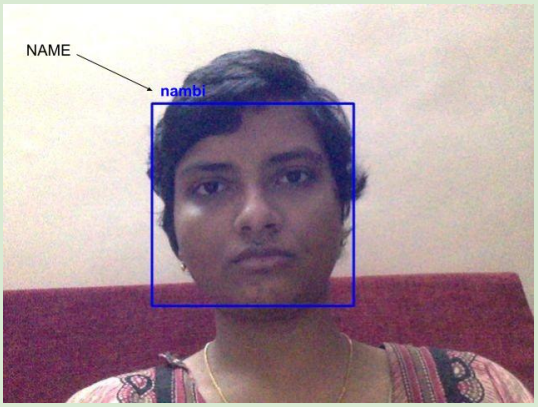
Face Recognition Tests

([Video Clip])

Face Detection



Face Recognition



Database Simulation

We simulate the functioning of the database using a [Python script], representing an initial list of patients and visitors that gets updated over time, removing visitors who have not been detected for 60 minutes, providing medicine to patients when prompted, adding visitors on arrival, and performing similar activities. Given here are three snippets corresponding to 0420 hrs, 0550 hrs, and 0720 hrs. ([Video Clip])

T = 260

Name	Age	Status	MED	LAST_DETECT	LAST_SAN
Sabu John	57	V	0	240	240
Michael Collins	55	P	0	240	240
Joe Tait	73	V	0	240	240
Francis Davenport	71	P	0	240	240
Lindsay Manchin	45	P	0	240	240

T = 350

Name	Age	Status	MED	LAST_DETECT	LAST_SAN
Sabu John	57	V	0	290	240
Michael Collins	55	P	0	240	240
Francis Davenport	71	P	1	240	240
Lindsay Manchin	45	P	0	240	240

T = 440

Name	Age	Status	MED	LAST_DETECT	LAST_SAN
Michael Collins	55	P	0	240	240
Francis Davenport	71	P	1	240	240
Lindsay Manchin	45	P	0	240	240
Lauren Mac	29	V	0	420	420

References

1. *TIAGo Tech. Specifications*, https://pal-robotics.com/wp-content/uploads/2020/05/TIAGo-Datasheet.pdf
2. *Webots Documentation*, https://cyberbotics.com/doc/guide/tutorials
3. *Webcam-based Face Recognition using Deep Learning*, https://github.com/DaneyAlex5/Webcam-based-Face-Recognition-using-Deep-Learning-
4. Pages, Marchionni, Ferro, *TIAGo: the modular robot that adapts to different research needs*
5. Winiarski et al., *An intent-based approach for creating assistive robots' control systems*
6. Belmonte et al., *Optimal Image-Based Guidance of Mobile Manipulators Using Direct Visual Servoing*
7. Coşar, Fernandez-Carmona, Agrigoroaie, et al., *ENRICHME: Perception and Interaction of an Assistive Robot for the Elderly at Home*