Autonomous robot for fall detection and emergency alerts

Restoring my grandmother's independence

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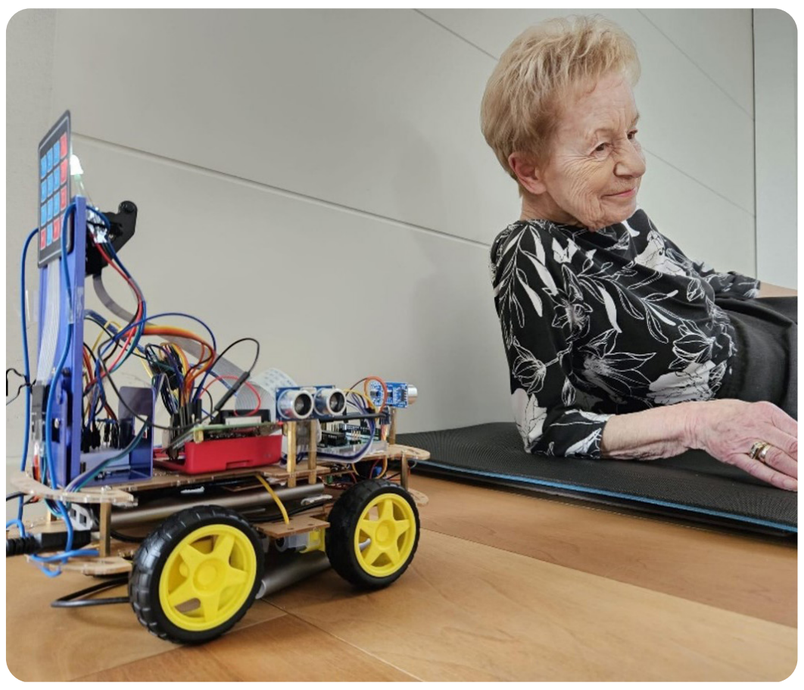
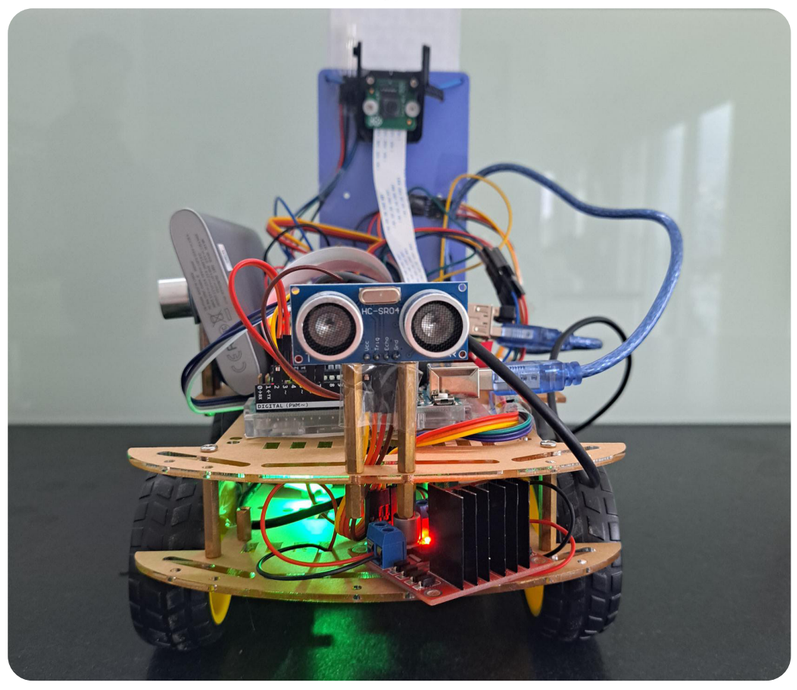
Elderly people suffer more frequent and more severe falls as they age. To ensure swift treatment for their injuries, I invented, designed and programmed a robot that can navigate autonomously with sensors collecting spatial data. Based on a neural network, I trained a computer vision model that enables the robot to detect falls. The robot's alert system allows it to send emails with attached pictures of the person lying on the floor.

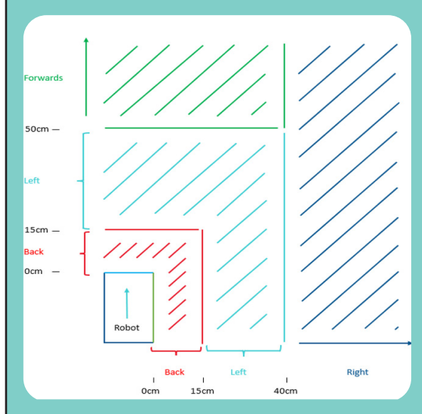
Video:



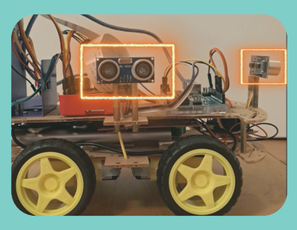


Navigation

As a relatively simple method for autonomously navigating an apartment, the robot's primary guideline for movement is to follow walls. This process necessitates two ultrasound distance measurements (front and right) for the robot to decide between four possible activities: reversing, turning left, driving forwards and turning right.



Right	Front	Activities
≤ 15 cm	≤ 15 cm	Backwards
≤ 40 cm	< 50 cm	Left
≤ 40 cm	≥ 50 cm	Forwards
> 40 cm	> 0 cm	Right

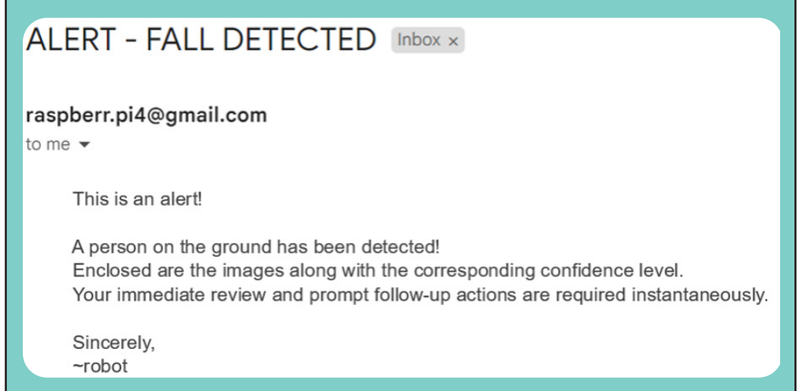


Object detection

To distinguish between a 'lying' and a 'not lying' person I trained an object detection model with a database of 3325 self-taken pictures using the neural network Yolo-v8. The model then successfully indicated whether an 'object' i.e. a 'lying' person had been found—if so, it outlined the person and returned values such as its confidence in its own assessment.

Alerting

To alert external help when a person lying on the floor was detected, the robot sends an email requiring immediate assistance and includes pictures of the person in need. Furthermore, I am currently developing a language processing model that allows the robot to interact with the person and provide emergency contacts with more insights into the situation.



ALERT - FALL DETECTED Inbox ×

raspberr.pi4@gmail.com
to me

This is an alert!

A person on the ground has been detected!
Enclosed are the images along with the corresponding confidence level.
Your immediate review and prompt follow-up actions are required instantaneously.

Sincerely,
~robot

Evaluation

In order to test the quality of my robot's assessments of people in different situations I let the robot take and evaluate 716 pictures. I then coded the data by manually assigning values to each of the investigated parameters—most importantly, whether the robot had correctly identified fallen people. I was thereby able to determine when the robot operated flawlessly, pinpoint its constraints, and understand the elements upon which its success or failure hinges.

ng num	experime	evaluation of det	num people	known/ -	Object	position	robot	exp. Obj	detected
392	0	true pos	1	0	m	right	head	1	1
393	0	true pos	1	0	m	right	back	1	1
394	2	false pos	0	0	none	none	front	0	1
395	0	false neg	1	0	m	stom	back	1	0
396	0	true pos	1	0	m	right	feet	1	1
397	0	true pos	1	0	m	back	feet	1	1
398	0	true pos	1	0	m	back	feet	1	1
399	0	true pos	1	0	m	back	feet	1	1
400	0	true pos	1	0	m	back	feet	1	1
401	0	true pos	1	0	m	stom	feet	1	1
402	0	true pos	1	0	m	right	feet	1	1
403	0	true pos	1	0	m	back	feet	1	1
404	0	true pos	1	0	m	back	feet	1	1
405	0	true pos	1	0	m	back	feet	1	1
406	0	true pos	1	0	m	back	feet	1	1
407	0	true pos	1	0	m	stom	feet	1	1

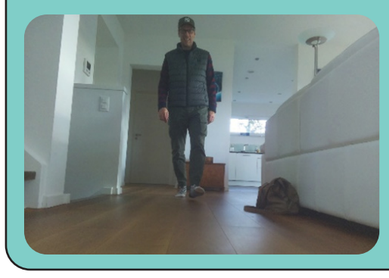
Assessment Cases

To assess whether the robot accurately matched images it retrieved to how it was trained I distinguished four cases:

True Positive
Correctly detected

False Negative
Should have detected but did not (person in danger)

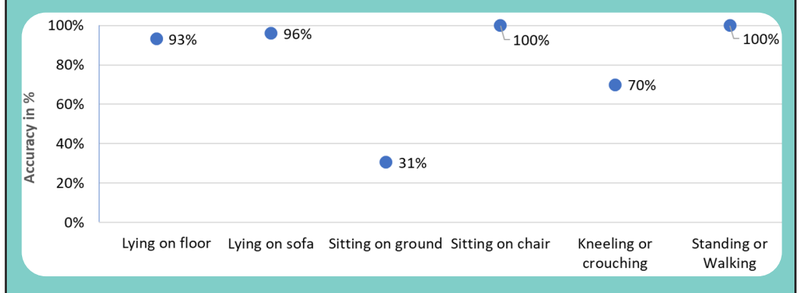
True Negative
Correctly not detected



False Positive
Detected but should not have (false alarm)

Results

The main results are that the robot correctly identifies "lying people" with an accuracy of over 80%, and that "walking" as well as "chair-sitting" people are correctly classified as "not-lying." However, problems in identification seem to arise when people are sitting on the floor.



In sum, the newly built robot is able to function as a safe-guard for elderly people to reliably detect falls and alert help. It can thereby serve as a prototype for further developments towards a marketable product to prolong independence of the elderly.