LOCATING ITEMS USING A MOBILE ROBOT IN A DOMESTIC ENVIRONMENT

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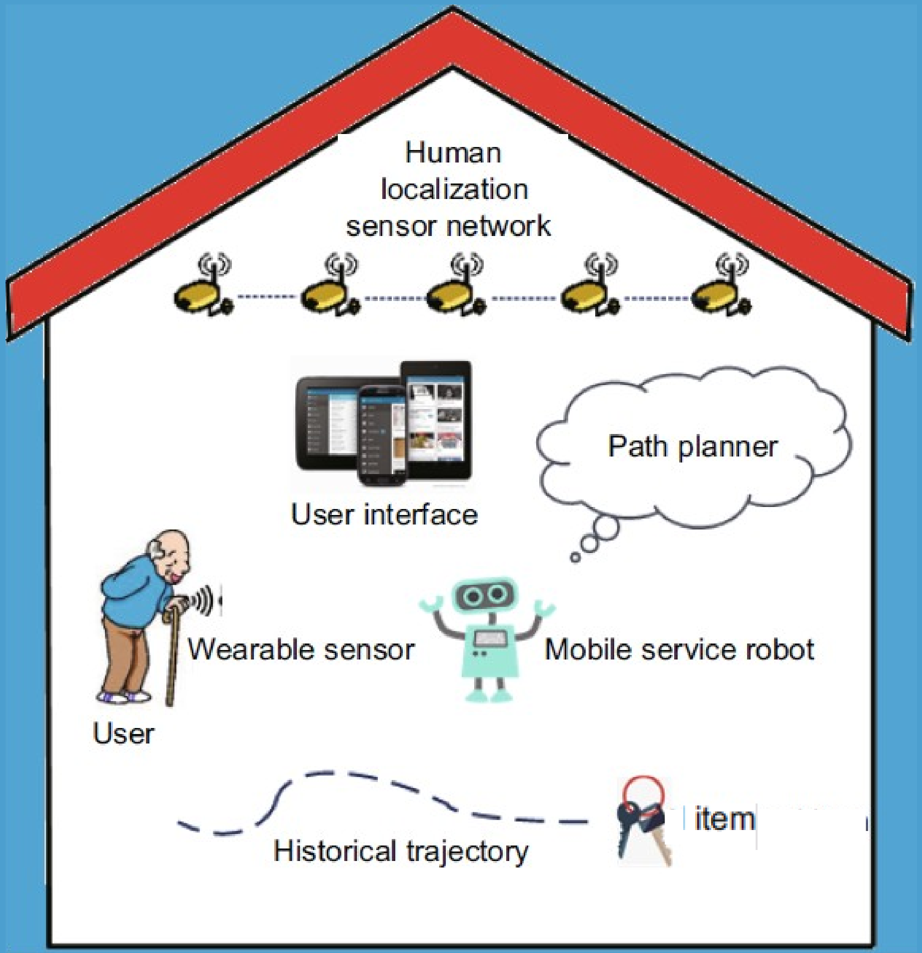
MOTIVATION

- More service robots needed for older population for elder care.
- Due to declining memory, assistance is required for locating some household items
- Hence, an autonomous robot search system is highly desirable to search for household items in home environments.

STEPS

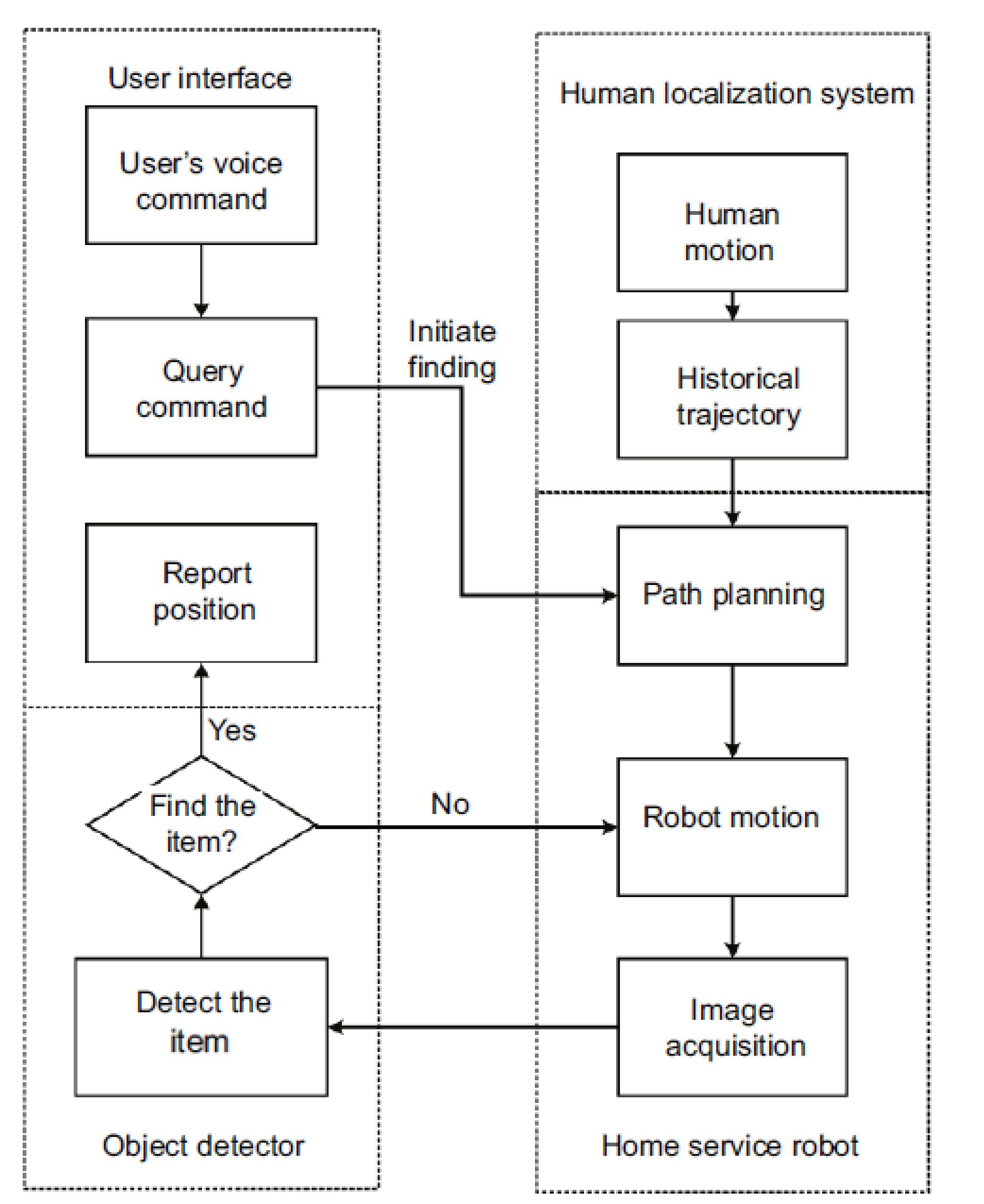
1. Human location detection
   - Data fusion method between a wearable sensor and multiple distributed movement detection sensors to estimate the historical trajectory of a resident.
2. Search path planning
   - Develop a robot path-planning method in which a preferable robot search path can be generated using knowledge of the human historical trajectory data.
3. Vision-based object recognition
   - Perform search using CNN

Concept of the robotic item finding system



Wang, Q., Fan, Z., Sheng, Wh. *et al.* Finding misplaced items using a mobile robot in a smart home environment. *Frontiers Inf Technol Electronic Eng* **20,** 1036–1048 (2019).[Digital image]. Retrieved from https://doi.org/10.1631/FITEE.1800275

PROCEDURE FOR ROBOTIC SYSTEM



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6.1

HARDWARE

Home-

- Passive infrared (PIR) sensor - Panasonic EKMC1601111, connected to an Arduino microcontroller board.
- An XBee shield and module mounted on the Arduino board

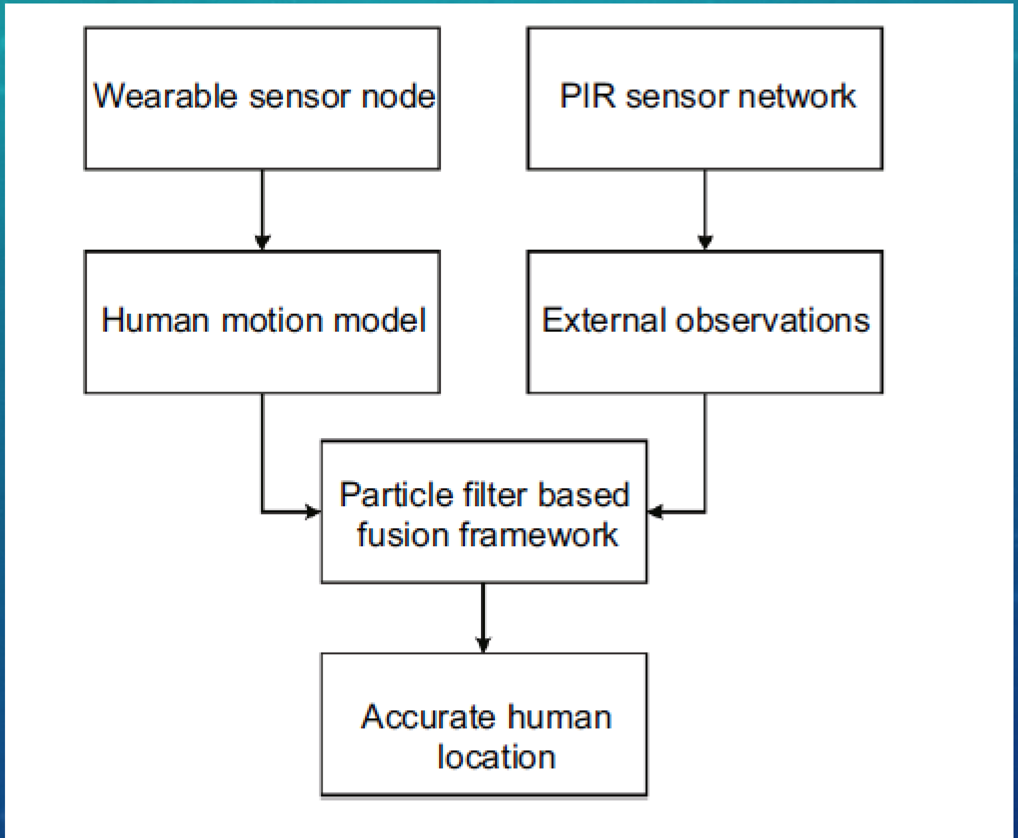
Robot-

- A mobile robot base- TurtleBot platform
- A laptop- a dual-core processor, Robot Operating System (ROS, 2018)
- A fixed-focus RGB-D camera
- A laser range finder (LRF) mounted on the top of the mobile base

Wearable sensor node-

- SensorTag v2 from TI
- Bluetooth low-energy (BLE) peripheral slave device based on the CC2650 multistandard wireless microcontroller unit(MCU) platform.
- MCU- nineaxis motion MPU-9250
- CC2540 universal serial bus (USB) dongle acts as a central device (BLE master)

1. HUMAN LOCATION ESTIMATION



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FUSION ALGORITHM FOR LOCALIZATION AND TRACKING

1: Initialize P particles with location vector $\boldsymbol{L}^i_k$, heading θ^i_k , and weight $\omega^i_k = 1/P$ ($i = 1, 2, . . . , P$)

2: Recognize human activity a_k and read z^{PIR}_k from the PIR sensor network

3: if A walking step k is detected then

4: Estimate walking step length d_k and heading angle θ_k. Propagate the particles according to Eq. (7) // prediction step

5: Update the weights of the particles according to Eq. (10) // update step

6: if $N_{eff} < N_t$ (N_{eff} is calculated by Eq. (12) and N_t is the judgment threshold) then

7: Implement the resampling procedure

8: end if

9: Estimate human location according to Eq. (13)

10: end if

11: Go to step 2

2. SEARCH PATH PLANNING

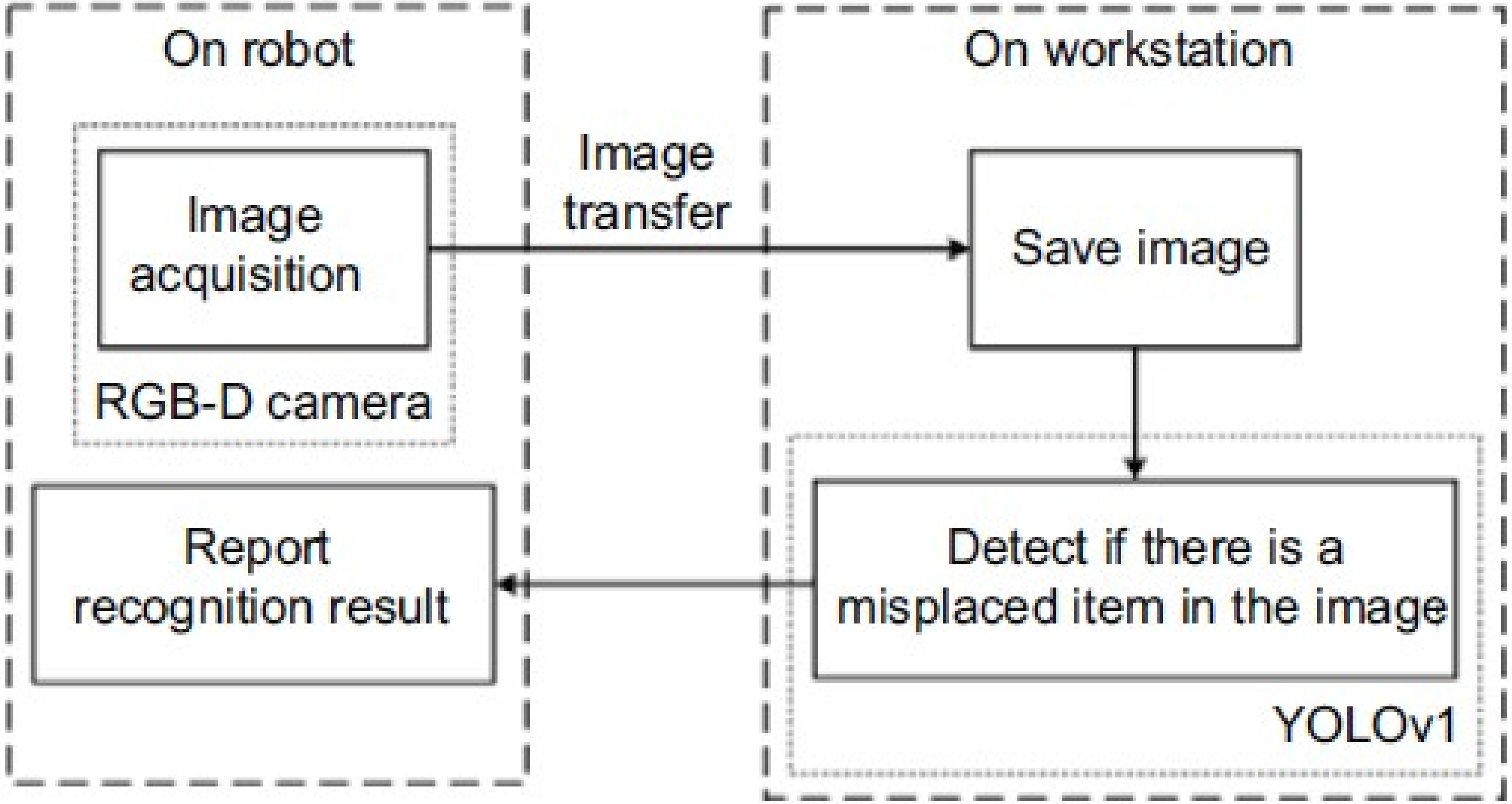
9.1

- Problem - how to use the human historical trajectory information to compute a preferable search path that minimizes the expected search time of the misplaced item
- Generate a preferable search path- used modified genetic algorithm that considers the prior human trajectory information given in the previous subsection. Global map is converted into a grid map.
- Robot conducts visual search by rotating itself. Visual range is key factor.
- By direct search method, number of possible region transition sequences grows by a factorial with the number of partitioned regions
- Adopted genetic algorithm (GA) for sequence planning problem

3. VISION BASED OBJECT RECOGNITION

- Two modules required: one for image acquisition on the robot, other for image processing on a workstation.
- RGB scene images from robot's camera and sent to the workstation
- The CNN produces three types of outputs from the scene images: the class probability, the bounding box coordinates, and a confidence value.
- Outputs evaluated and generates two classes: "item" and "no item."

OBJECT RECOGNITION ARCHITECTURE



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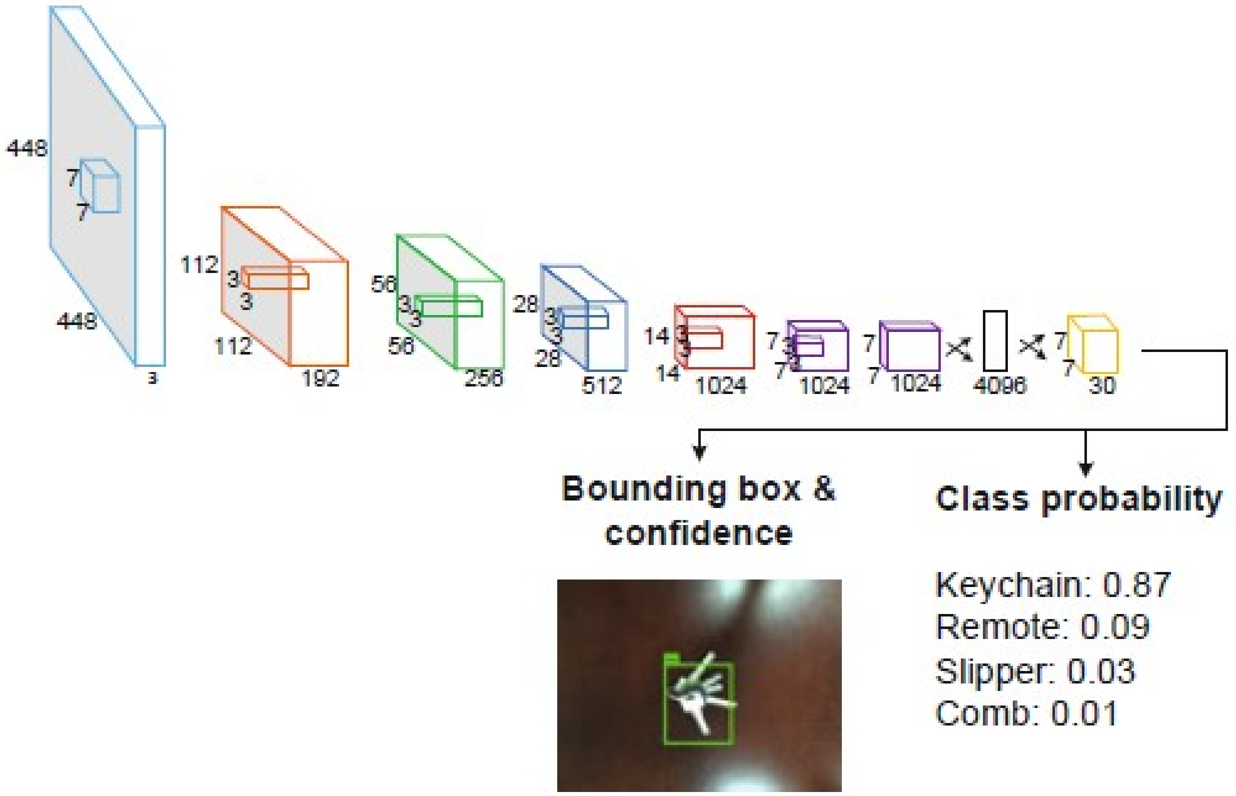
CNN ARCHITECTURE



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WALL AND DOOR DETECTION

- Some domestic object classes that are not suited to this approach such as doors and walls
- Framework of fusing 2D local and global features such as edges, textures and regions with geometry information obtained from pixel-wise dense stereo for reliable 3D indoor structural scene representation

EXPERIMENTAL EVALUATION

- Three different performance metrics used to evaluate the efficiency of the proposed approach
  - The total time consumption (Tfound)
  - The total length of the path (Len)
  - The total angle of rotation (Ang)
- Proposed method took 49% less time to complete the search task, and an average of 47% less distance and 52% less rotation, which means that the proposed method is much more efficient in MIF than the benchmark methods.

- The robot stays on ground and performs search so it may miss things in house which are high enough from the ground and out of it’s camera’s range.
- The evaluation is based on one item of search, keys. Experiment should be done on multiple objects and overall performance should be measured

15.1

REFERENCES

- Wang, Q., Fan, Z., Sheng, Wh. *et al.* Finding misplaced items using a mobile robot in a smart home environment. *Frontiers Inf Technol Electronic Eng* **20,** 1036–1048 (2019). https://doi.org/10.1631/FITEE.1800275
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THANK YOU

Index of comments

6.1 an image of the robot and/or the wearable would be nice

8.1 the pseudocode is somehow hard to read. maybe you could change the layout and/or to color markup

9.1 too much text, make it shorter

10.1 is this trained to only locate one specific item?

15.1 good points