Radiation Detection after Thryoid Treatment

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1. Abstract

Many thyroid complications are treated with radioactive Iodine (I-131). The radioactive patient is then hospitalized afterwards to avoid exposing others to harmful levels of radiation. To instead be discharged immediately, a mechanism that alerts individuals (i.e. family members) of dangerous radiation exposure is required. A previous semester designed a belt that uses a thermal and proximity sensor that beeps when an individual is within a one meter range of the patient.[1] Our client, Dr. Sarah Hagi, a radiologist at King Abdulaziz University Hospital, proposes the creation of a device that more accurately alerts individuals of total radiation exposure. The proposed design incorporates Bluetooth technology to calculate family member's total radiation exposure as a function of proximity to the patient and time.

Background/Motivation

Client: Dr. Sarah Hagi, radiologist at King Abdulaziz University in Jeddah, Saudi Arabia.

Figure 1. PIcture of the Thyroid[1]

Background:

- Two hormones produced by the thyroid, T3 and T4, are important in metabolic regulation.
- Iodine makes up portions of the T3 and T4 hormones, so iodine in the blood stream is naturally absorbed by the thyroid.
- Hyperthyroidism and thyroid cancer are treatable using radioactive doses of iodine.[2]

Motivation:

- Patients are released shortly after receiving radioactive doses of iodine
- Family members taking care of patients are at risk of accumulating dangerous levels of radiation exposure
- A design to track total radiation exposure and alert each individual when they are at risk of being exposed to too much radiation was proposed

3. Design Specifications

- Able to detect human presence within a 1 meter distance.
- Ability to track radiation exposure for each family member.
- Comfortable to wear throughout the day
- Must be safe: not be affected adversely by radiation, and all electrical components, and the eletrical components able to be concealed

4. Design

Features:

- Beacon and receiver model to track distance and exposure.[3]
- Beacons used are 3 Estimotes, $99 total
- Created Android App using Estimote SDK
- Tracks distance between phone and each beacon separately of each other
- Tracks radioactive I-131 exposure of each beacon based on distance
- Displays each value on interface
- Vibratory feedback if range is less than one meter

$$A = 600 \cdot \left(\frac{1}{2}\right)^{\left(\frac{T}{8.02}\right)} \qquad R = \left(\left(\frac{A}{2.065404475}\right) \cdot (100\,d)^{-2}\right)$$

Figure 3. Radiation exposure equations. Includes patient radioactivity based on half-life (left) and gamma radiation exposure based on radioactivity and distance (right).[4]

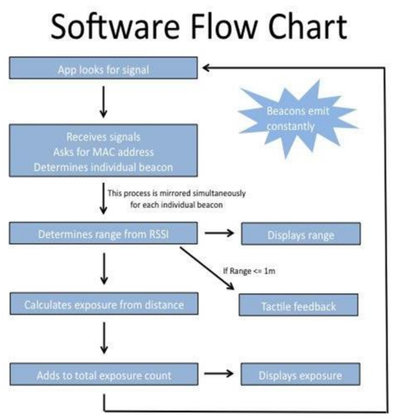

Figure 2. Flow chart representing the logic patterns followed in software of the RaDistance Android App.

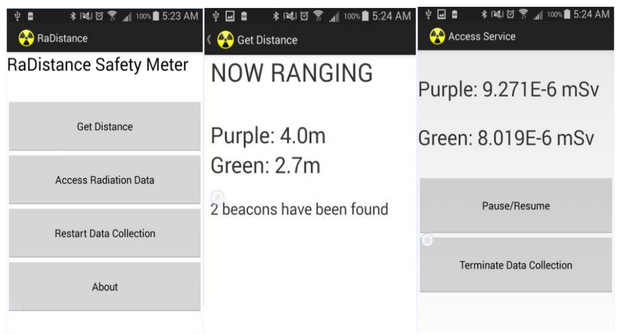

Figure 4. Three displays in RaDistance App. Shown left is the App's home screen which shows a very simple user interface. Shown middle is the 'Get Distance' feature displaying range between beacon and receiver. Shown right is the 'Access Radiation Data' feature displaying cumulative radiation exposure for each beacon.

5. Testing

Single Beacon Testing:

- BLExplr[5] on iOS and RaDistance on Android
- Accuracy at 10 cm increments were tested, up to 1 meter
- Each distance was averaged over 10 trials

Multiple Beacon Testing:

- BLExplr on iOS
- One beacon was kept stationary 70 cm away at an angle of 45° while other one ranged from 10-100cm
- Each distance measurement was averaged over 10 trials

Vibraratory Feedback Testing:

- RaDistance on Android
- Beacon "family member" was fixed, and phone "patient" moved slowly to within 1m
- Average response time over 10 trials was 2.49 seconds.

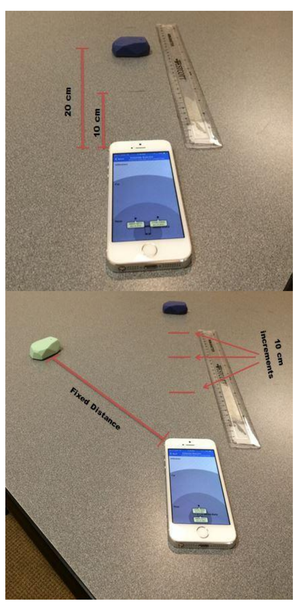

Figure 5. Testing setups for distance accuracy. Test 1 (top) measured 10 cm intervals up to 1 m, while test 2 (bottom) did the same but with a 2nd beacon at a fixed distance and angled away.

6. Results & Discussion

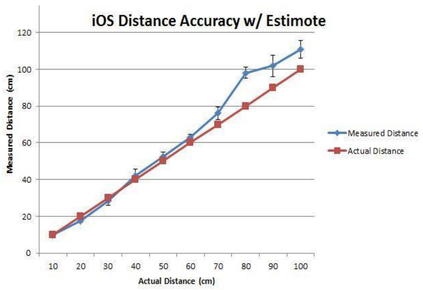

Figure 6. Analysis of distance testing with iPhone 5 and a single Estimote beacon, error bars represent standard deviation for data set at each distance

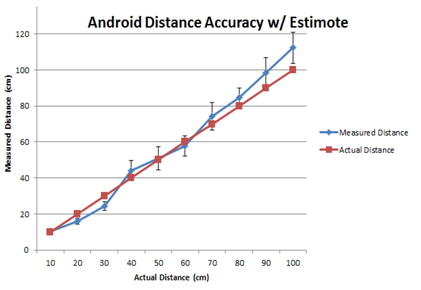

Figure 7. Analysis of distance testing with Android App and a single Estimote beacon, error bars represent standard deviation for data set at each distance

Discussion

- Averages fairly similar overall in both platforms
- iOS showed higher accuracy at shorter distances
- Error bars smaller everywhere
- iOS noise reduction
- Fixed beacon hovers around 70 cm
- Mobile beacon less accurate beyond a half meter
- Signal interference

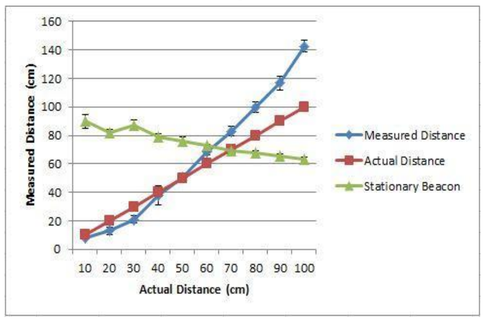

Figure 8. Analysis of distance testing with iOS using one fixed beacon at 70 cm, and another beacon moving in increments of 10 cm.

7. Future Work

Devices:

- Produce self-made beacons
- Produce self-made receiving device
- Adapt the beacons into more user friendly device, such as bracelet
- Improve range calculations

Programming:

- Make interface more user friendly with more aesthetically pleasing app appearance
- Mirror app onto more platforms, such as iOS or stand alone
- Improve range calculations
- Adapt algorithm if necessary

8. Acknowledgements

We'd like to thank our advisor, Professor Walter Block, as well as our clients, Dr. John Webster, and Dr. Sarah Hagi.

9. References

[1] Goss, Jack. Radiation Distance Safety Meter N.p., 11 Dec 2013 Web. 7 Oct. 2014.
[2] Barrington, Sally F., et al. "Radiation exposure of the families of outpatients treated with radioiodine (iodine-131) for hyperthyroidism." *European journal of nuclear medicine 26.7* (1999): 868-692.
[3] *Bluetooth Indoor Localization System* (n.d.): n. pag. Web. 18 Sept. 2014.
[4] Zanzonico, Pat B., et al. "A generalized algorithm for determining the time of release and the duration of post-release radiation precautions following radionuclide therapy." *Health Physics* 78(6) (Jun 2000): 648-659.
[5] Michael Kroll. App Store on iTunes. *BLExplr* 2014.