RADIATION DISTANCE SAFETY METER

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Abstract

Problem

Nearly 200 million people are affected by thyroid disorders worldwide. The thyroid gland is crucial for metabolic processes and hormone regulation, and serious symptoms can arise when the thyroid gland is malfunctioning. Treatments of thyroid disorders include medications and lifestyle changes. However, in more severe disorders such as cancer and hyperthyroidism, radioactive iodine (I-131) is utilized to destroy malignant tissue surrounding the thyroid, sometimes also including the thyroid. Due to its radioactive properties, radioiodine can also damage healthy tissues of those near the patient in treatment.

Purpose

We designed a device that alerts the patient when he or she is within close proximity of another person. This device must alert the patient when a human is detected within a 1.0 m radius, as well as function continuously through a single battery charge of 16 h.

Final Design

The final prototype was composed of two distance and two thermal sensors coupled on a nylon belt that were, powered by a nine volt battery and controlled with an arduino microcontroller. Additional features include indicators to the user in the form of LEDs and buzzers, allowing for quick and efficient feedback of proximity data.

Introduction

Radioiodine (^{131}I)

- β radiation kills cells within 2 mm (e.g. overactive/cancerous thryoid cells)
- Γ radiation poses danger to surroundings up to 2 m away[1]
- Half-life of 8.0 days[2] (Figure 2)

Medical Practices

- Orally ingested radioiodine pills[3]
- Timespan of 4 to 6 weeks for radioactive decay[4]

Previous Design Limitations

- Bluetooth beacon with iPhone app connection required by detected subjects
- Required smart phone ownership
- Must be preconfigured
- Expensive

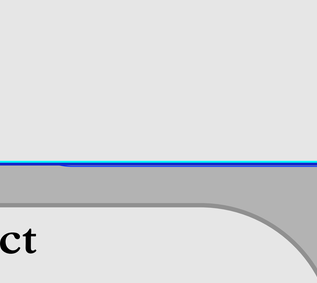

Figure 1: Previous team's testing setup with Bluetooth beacon and iPhone.

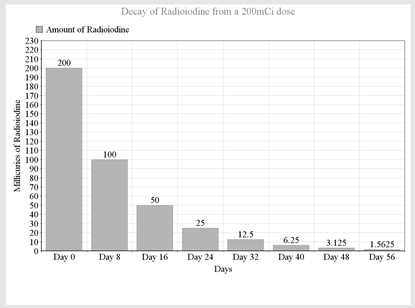

Figure 2: Radioiodine decay over eight weeks[4].

Design Criteria

Safety

- Ability to warn the patient of close human proximity
- No risk of electrocuting the user
- Device weight < 0.5 kg

Performance

- Accuracy of detection within a +/- 10 cm range
- Field of view at least 120°
- Immediate human proximity indication via lights and buzzer
- Battery longevity at least 16 h

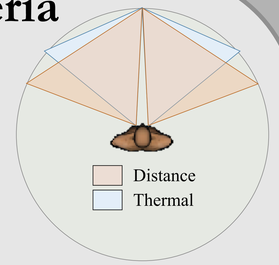

Figure 3: Theoretical sensor field of view.

Maintenance and Operation

- Ability to connect device to a computer for calibration and functionality updates
- Fully operational for extreme temperatures between -25° and 50° C and humidities between 5% and 95%

Final Design

Components

- Double Layered Nylon Belt 86 cm x 4 cm
- Omron D6T8L06 Thermal Sensor
- LV-Maxbotix EZ0 Distance Sensor
- RGB LED Strip
- 5 V Vibrational Motor
- Arduino Pro Mini 5 V

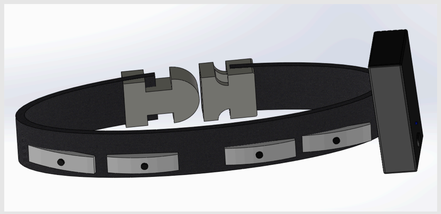

Figure 4 (above): SolidWorks drawing of belt prototype with two pairs of coupled sensors, one distance and one thermal, and main housing unit (RGB LED strip not shown).

Figure 5 (left): Final prototype as worn by patient.

Methods

Field of View

- Belt placed against wall
- Slid jar of hot water into view at 10 cm intervals from each side up to 1.0 m away
- Marker placed at each spot of detection
- Trial performed three times

Range

- Belt placed against wall
- Slid jar slowly entered towards belt starting at 2.0 m away
- Marker placed at each spot of detection
- Trial repeated ten times

Testing & Results

Table 1: Field of View (one sensor pair). Statistical data from field of view testing.

Center Distance (cm)	Angle Mean (°)	Angle Standard Error (°)
10	50.15	2.31
20	45.85	0.75
30	48.62	1.60
40	44.85	1.38
50	48.78	2.79
60	47.67	1.70
70	47.54	2.04
80	45.93	0.86
90	45.60	0.89
100	45.13	0.73
Total	47.01	1.11

Figure 7: Field of view testing with one sensor pair.

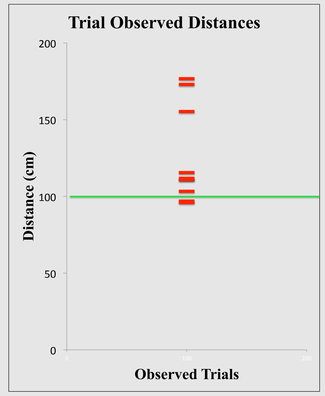

Figure 6: Range (center of belt). Plot of ten centered range trials.

Table 2: Range Statistics. Analysis of range test data.

Observed Mean (cm)	124.99
Differential Mean (cm)	24.99
Standard Error (cm)	9.79

Future Work

Design

- Internal circuitry and components
- Rechargeable battery
- Sizable

Software

- Saves data from daily use
- Bluetooth module for phone communication

Testing

- Accuracy
  - Current sensors
  - New sensors
  - Thermal detection through clothing
- Real world trials

Acknowledgements

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References

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[4] S. Baunfire.com, *Thyca.org*, 2015. [Online]. Available: http://www.thyca.org/pap-fol/rai/. [Accessed: 09- Feb- 2015].