Human Activity Monitoring Through Magnetic Induction

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SHINE
Summer High School Intensive in Next-Generation Engineering

INTRODUCTION

The world is changing faster than ever, and e-health or web-enabled healthcare systems are the future of personalized healthcare, which enable remote monitoring of the patient health and point-of-care testing and diagnosis. Wearable on-body sensors can be placed on the body to form a wireless body area network (WBAN) which are used to monitor the human activity. Magnetic induction (MI) emerges as a low power approach to achieve this goal as will be shown in this work for monitoring joint flexion.

MAGNETIC INDUCTION FOR MONITORING JOINT FLEXION

Human body physical activities can be monitored by sensing magnetic induction-based motion signals. The magnetic link strength (represented by the mutual inductance) between the receiver and transmitter coils is function of the separating distance and the coils orientation and alignment. Since the human body is transparent to the magnetic fields up to given frequency of around 30MHz, joint flexion angle was monitored by recording the received power from an excited transmitter at a 2.048MHz frequency (see Fig. 1).

METHODOLOGY AND RESULTS

Magnetic link model was setup in MATLAB between two identical magnetic coils (48mm nominal radius, 10 AWG wire, and one turn). The transmitter (TX) is placed close to the wrist at a distance GAP from the joint, while the receiver (RX) is placed on the other side of the joint at a fixed distance of 15 cm as shown in Fig. 2. The TX was moved in a circular movement varying the flexion angle from 0 to 135 degrees.

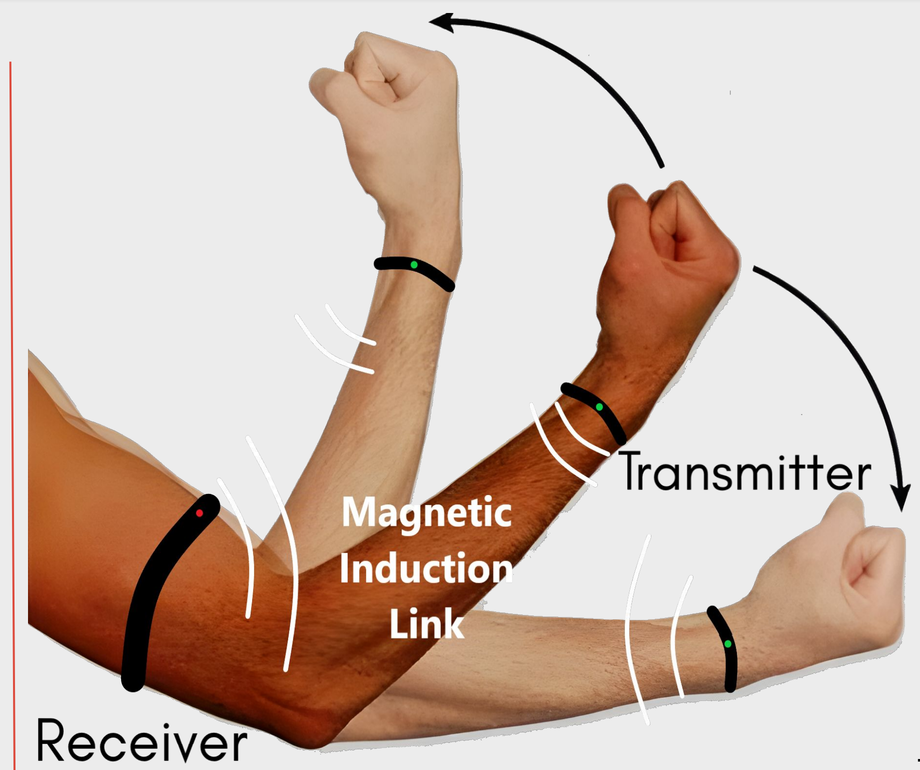

Fig. 1. Joint flexion monitoring using wearable magnetic coils.

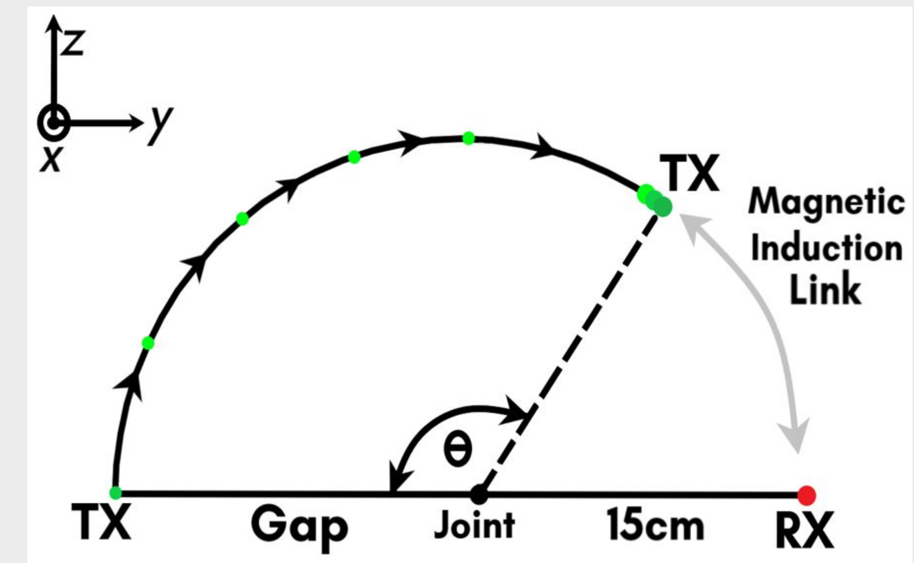

Fig. 2. Joint flexion diagram. Adapted from: https://aakash-qrc.s3.amazonaws.com/2020-05-28%2008:32:42.172flexion.PNG

METHODOLOGY AND RESULTS (Cont.)

The MI MATLAB model takes the TX and RX separation distance and alignment (coil center and surface normal vector) as inputs and calculates the output received power of a lumped circuit model of the MI link. The received power is plotted as function of the joint flexion angle for different TX/RX coil radii (30mm, 48mm, and 100mm) as shown in Fig. 3. The received power is also plotted as function of the joint flexion angle for different joint to transmitter gap separation (15cm, 20cm, and 25cm) as shown in Fig. 4.

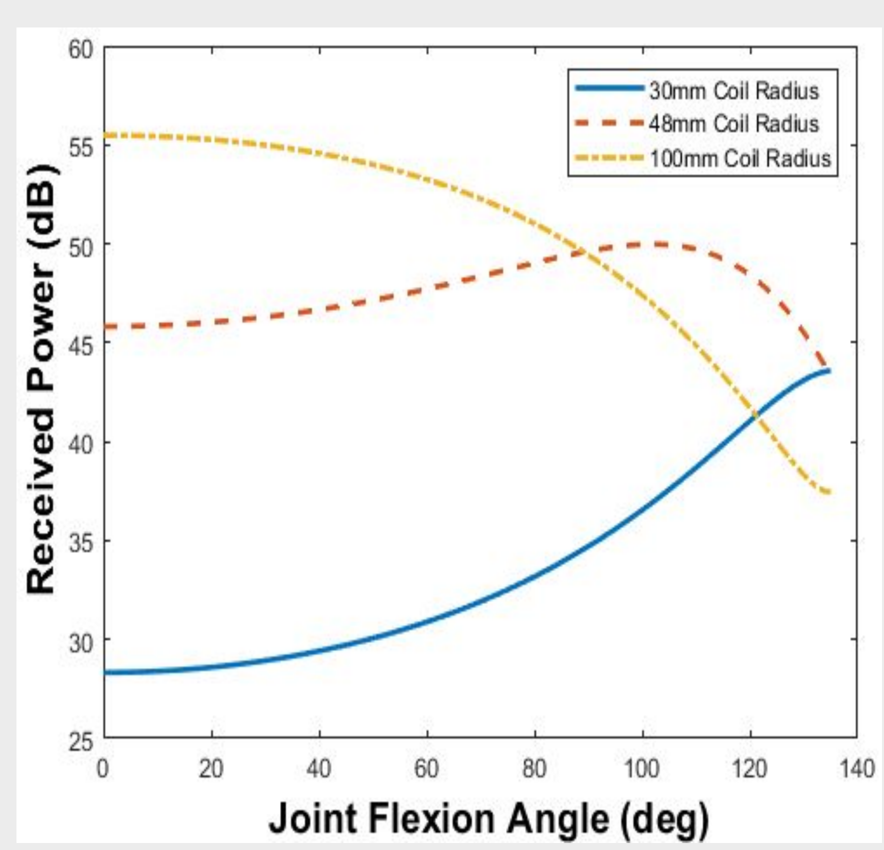

Fig. 3. Received power (dB) as function of joint flexion angle (degrees) for three different TX/RX coil radii.

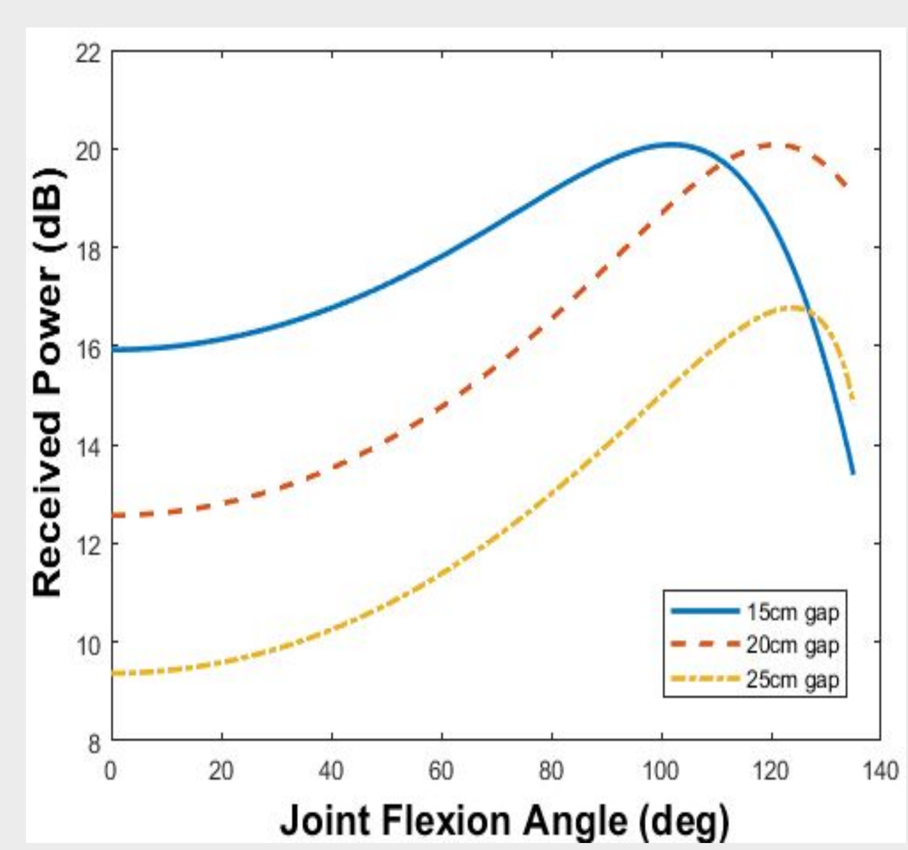

Fig. 4. Received power (dB) as function of joint flexion angle (degrees) for three different joint to transmitter gap separation.

HOW THIS RELATES TO MY STEM COURSEWORK

In my SHINE journey, I got to do actual research with my professor and my mentor, providing me with many valuable takeaways. My entire family has been in the aerospace industry as engineers, professors, and entrepreneurs, so I am very familiar with STEM. I feel like in my journey, I finally got to do something I've heard my family do for so long. In the future, I hope I can improve my skills further and join university to make an impact in the world.

CONCLUSION

Although I was only at USC for 7 weeks, the experience I gained was huge and immensely valuable. I became proficient in reading state-of-the-art research papers and learning how to independently conduct my research. I learned a new programming language, MATLAB, and used it to synthetize magnetic-induction based signals, as well as for data post-processing. At the end, I am happy, and I feel a lot more experienced debugging and fixing problems and working independently in the future. USC SHINE was a brilliant journey where I learned new technical skills and met tons of wonderful people.

ACKNOWLEDGEMENTS

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