Handheld Sensor for Load Carrying

Eisa Anwar[1], Sajeeva Abeywardena[1], Stuart Miller[2], Ildar Farkhatdinov[1,3]

1: School of Electronic Engineering and Computer Science, Queen Mary University of London, London, UK e.a.m.anwar@qmul.ac.uk

2: Sports and Exercise Medicine, Queen Mary University of London, London, UK

3: Department of Bioengineering, Imperial College of Science, Engineering and Medicine, London, UK

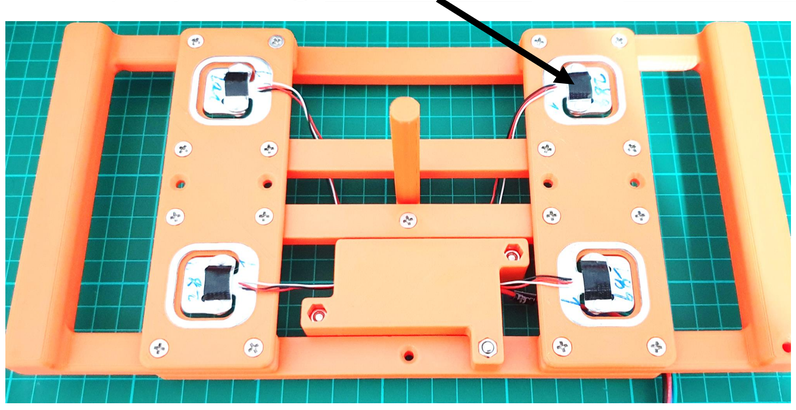
Engineering and Physical Sciences Research Council

Abstract

In many industries, human workers are required to manipulate heavy loads, e.g. warehouse operations, aircraft maintenance, etc. This can cause strain and injury over time[1][2]. Supernumerary Robotic Limbs or SRLs are extra limbs that can attach to the body. A tail-like appendage could be used to assist balance[3]. To control this, the offset in a user's Centre of Mass (CoM), caused by carrying loads, needs to be evaluated. We propose a sensor to measure this offset which can inform the control system of a balance assisting SRL.

Methodology

A custom hand sensor, was designed and manufactured. It measures the weight of a load and its distance from the body by using load cells and rotary encoders respectively.

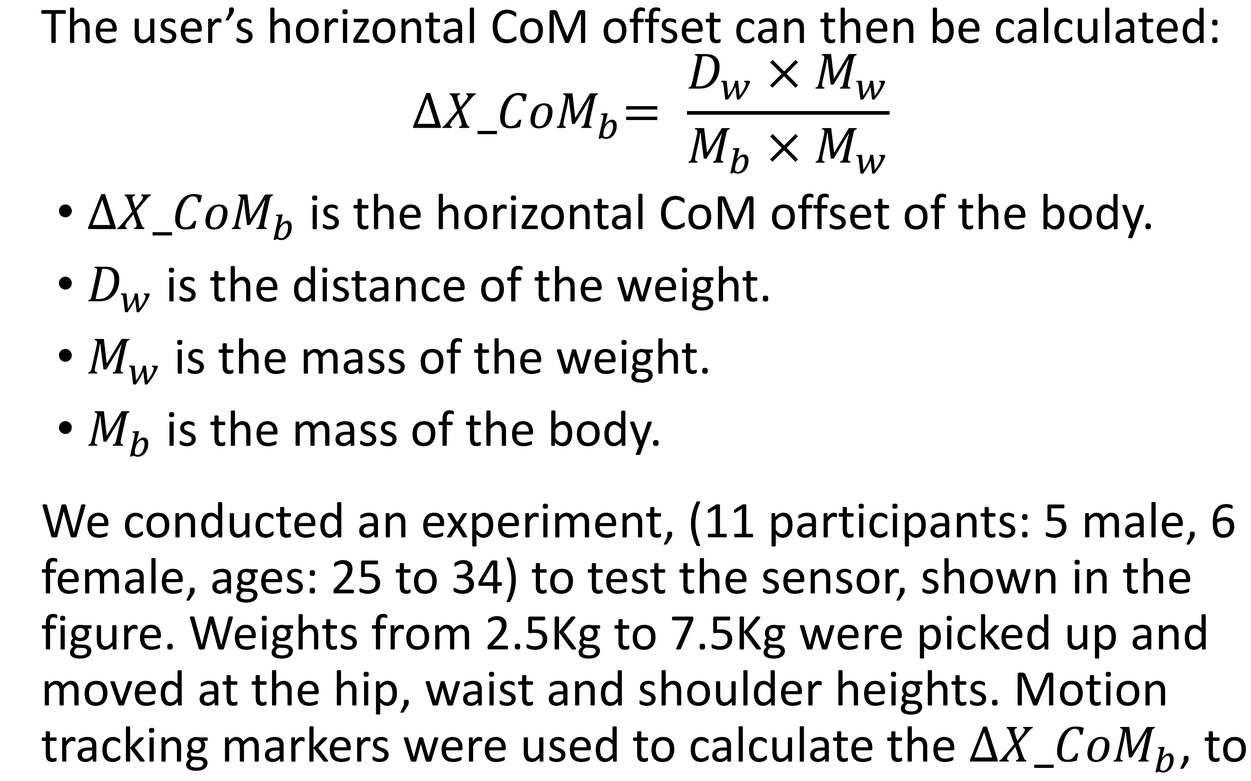


The user's horizontal CoM offset can then be calculated:

$$\Delta X\_CoM_b = \frac{D_w \times M_w}{M_b \times M_w}$$

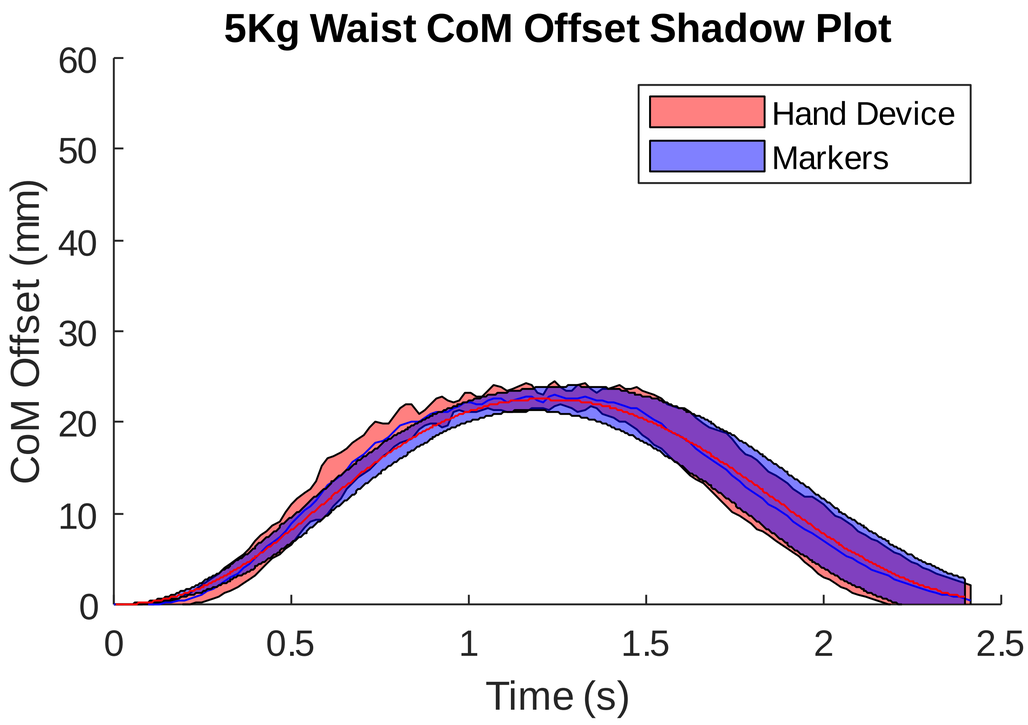
- ΔX_CoM_b is the horizontal CoM offset of the body.
- D_w is the distance of the weight.
- M_w is the mass of the weight.
- M_b is the mass of the body.

We conducted an experiment, (11 participants: 5 male, 6 female, ages: 25 to 34) to test the sensor, shown in the figure. Weights from 2.5Kg to 7.5Kg were picked up and moved at the hip, waist and shoulder heights. Motion tracking markers were used to calculate the ΔX_CoM_b, to assess the accuracy of the value calculated by the sensor.

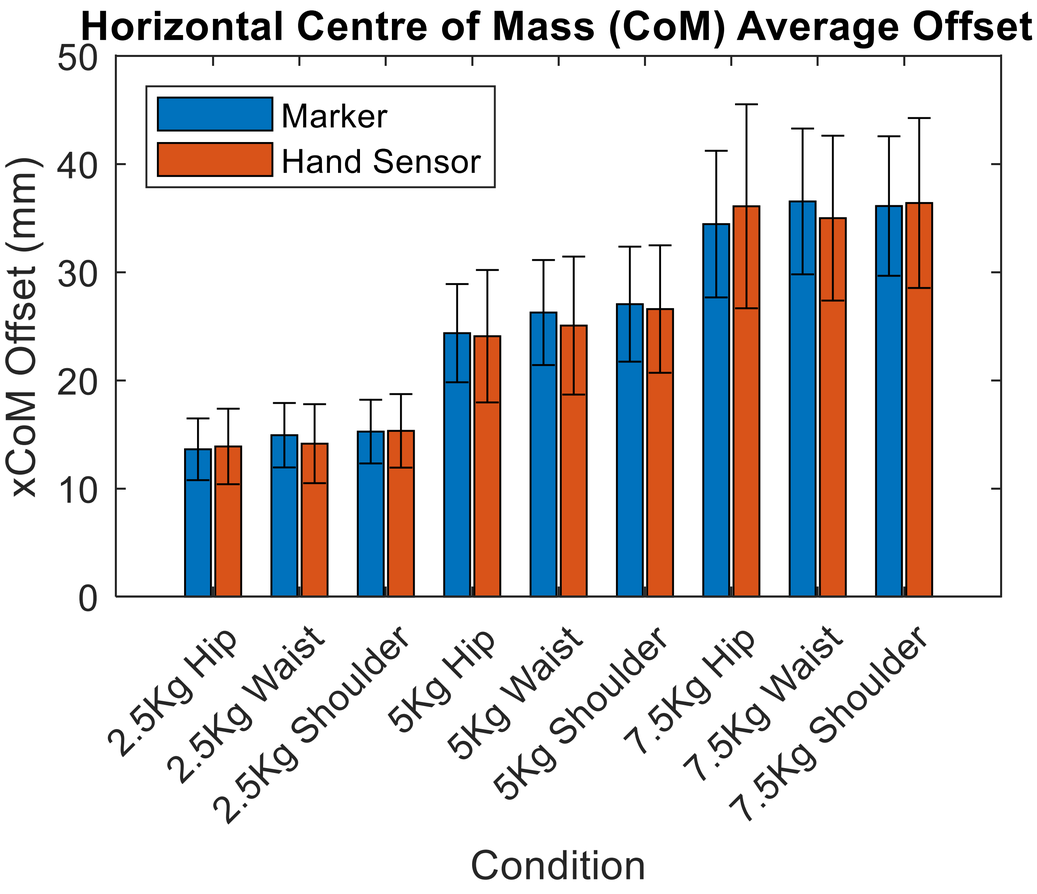


Results

This figure shows horizontal CoM offset measured by the hand sensor and the motion-tracking markers for a single trial. The single condition consists of 5 repetitions.



This figure shows the horizontal CoM offset measured by the hand sensor and markers for all conditions. All trials consists of 5 repetitions.



This figure shows each condition's average RMS error in mm. The average error is 2.65mm.

RMS Error For All Conditions From All Participants											
Participant / Condition	Part. 1	Part. 2	Part. 3	Part. 4	Part. 5	Part. 6	Part. 7	Part. 8	Part. 9	Part. 10	Part. 11
2.5Kg Hip	1.70	0.89	1.04	0.99	0.73	1.54	2.35	0.91	1.61	0.74	1.18
2.5Kg Waist	2.07	0.50	0.88	2.94	1.18	0.81	1.31	2.68	0.89	0.90	1.24
2.5Kg Shoulder	1.21	1.51	1.24	2.21	0.84	1.91	1.90	2.16	1.12	1.23	1.55
5Kg Hip	3.32	1.57	1.31	2.34	1.16	2.74	9.75	3.36	3.42	2.04	1.70
5Kg Waist	2.79	1.17	1.49	4.31	1.87	1.60	3.01	4.40	1.79	4.55	3.28
5Kg Shoulder	1.50	3.02	1.83	2.70	1.58	2.21	5.94	3.42	3.41	1.67	2.44
7.5Kg Hip	4.01	2.42	2.42	4.16	2.03	6.71	7.94	2.50	7.24	2.05	2.48
7.5Kg Waist	3.30	2.74	1.83	8.92	2.38	1.93	3.69	6.31	3.09	3.34	3.69
7.5Kg Shoulder	2.05	2.53	3.70	3.62	1.92	5.19	4.32	4.96	4.35	3.55	2.28

The sensor has a 90.0% average accuracy, demonstrating its effectiveness as an SRL controller input device.

References

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