Robust Wireless Real-Time Data Transmission for Robot Control in Neurorehabilitation

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Wireless data transmission is hardly used for direct control of robots in general. Particularly not in robots that are applied in human-machine interaction and even less in human-machine interaction in the medical sector. The main reasons why cable-bound data transmission remains the gold standard in human-machine interaction and haptics are: i) high and ii) constant data rates (usually 1[kHz]) iii) without data loss are required to render virtual environments reliably; iv) wireless transmission requires batteries and v) monitoring the charging status. However, cable-bound data transmission has also significant disadvantages: i) long cables add extra weight to the robotic device, ii) the dynamic behavior of the robot can be modified due to the spring-like behavior of the cables, and iii) for large robots, even additional motors may be required for cable guidance, which iv) increases material costs, v) space requirements and vi) energy consumption of the robotic device.

In our case, we are developing a large scale tendon-based robot for rehabilitation of gait disorders: the FLOAT V2.0. The FLOAT will be applied for spinal cord-injured patients or stroke patients and is based on our previous work [1]. Importantly, the FLOAT can provide constant body weight support during free walking, which is known to be beneficial in neural gait rehabilitation [2]. To enable training with constant body weight support, the end-effector force needs to be measured for force control. In the previous version of the FLOAT, force data was transmitted by cables. Due to the advantages of wireless data transmission, particularly with respect to the large workspace of the FLOAT (3.5x12x5m), we chose to apply wireless data transmission.

To account for possible data loss due to wireless data transmission, we have placed one radio frequency sender in the end-effector of the FLOAT (16h operational) and two receivers in opposite corners of the room. Both receivers are connected to the same EtherCAT network that records data at 1[kHz]. In case one receiver cannot properly receive data, the other receiver will kick in. In this way, data loss can be reduced to an acceptable and stable minimum, which could be shown in a ten minutes experiment for a lying and a moved sender (Figure 1).

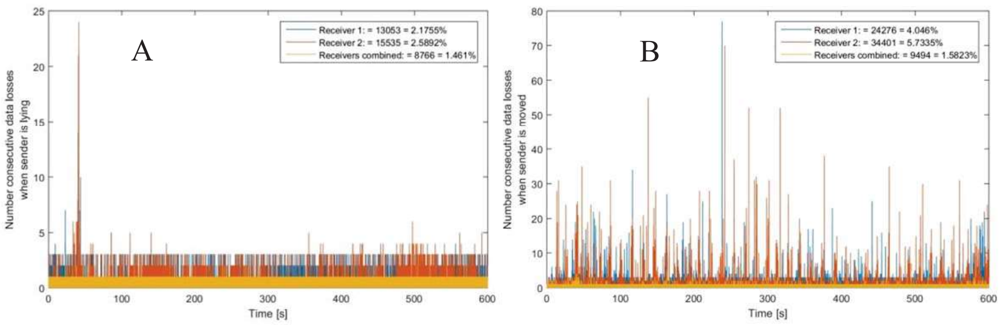

Figure 1 A,B: Loss of wireless transmitted real-time data in consecutive time frames. Data loss varies based on the data recorded from receiver 1, receiver 2, or the combined signals of both receivers. Data was recorded in real-time at a data rate of 1[kHz]. Figure 1A shows consecutive data loss when the sender is lying (max consecutive data loss receiver1=10, receiver2=24, combined receivers=2). Figure 1B shows data loss when the sender is moved (max consecutive data loss receiver1=77, receiver2=70, combined receivers=7).

References

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Acknowledgments

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