insufficient portions of the entire movement range (IQR of the sample less than 50% of mean IQR for the same movement across all subjects) were also removed from the prepared dataset. Validation boxplots for small digit MCP joint angle medians (per subject), before and after anatomical ROM filtering, are shown in Fig 1. For each of 16 investigated joints, similar validation graphs were plotted. Also, by investigating boxplots in Fig 1 (top), many outliers still remained in the data, so an additional 1.5 IQR outlier detection and removal procedure was performed. It is applied on a subject-level summary statistics, where all measurements, whose median fell outside range (Q1 - IQR, Q3 + IQR) was deemed outlier and removed from further processing. In Fig 1 (bottom) the example of summary statistics for MCP5, after preprocessing and outlier removal steps, is presented.

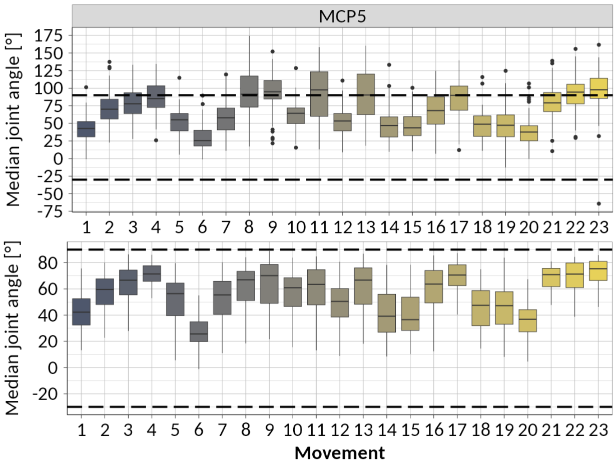

Figure 1. Validation for removing data points outside anatomical ROM.

3. Results and correlation analysis

After data preprocessing at a joint level, the subsequent steps involved forming 18 intra-finger dependencies, such that every combination of joint trajectories belonging to the same finger can be correlated using Pearson's *r*. Owing to data acquisition parameters, some repetitions comprised numerous measurements, while some only 100, resulting in disbalance in the dataset. Dependencies were observed on a repetition level as a unit for data analysis, thus balancing each subject share during further inferences since each subject performed 4 repetitions on average after data preparation. Correlation analysis was then performed, and more than 70 000 correlation coefficients obtained (matrices with combinations for each finger, movement, subject and repetition) for identifying further relationships. The same 1.5 IQR rule was then applied to correlation coefficients for each movement dependency to eliminate outliers. Only highly correlated intra-finger dependencies with absolute median correlation coefficient larger or equal to 0.7 (breakpoint according to [7]) were isolated. Outlier removal procedure example (for Movement 10, MCP5 - PIP5 dependency) is shown in Fig 2.

The correlation analysis resulted in dependency - movement matrix in Fig 3, where only the median coefficients are visualised. From a total of 18 investigated dependencies (y-axis in Fig 3), 16 were highly correlated during at least one movement, indicating a relationship, while ring and little finger DIP and PIP joints were the only ones not correlated. On the other hand, in each of the 23 investigated movements, there is at least one correlated dependency, while in movements 2 (power grip) and 3 (fixed hook grasp) a large number of joint dependencies (10 and 11 respectively) can be identified. Also, it can be concluded that the thumb is the most independent digit, with identified only 5 dependency-movement associations, agreeing with [3].

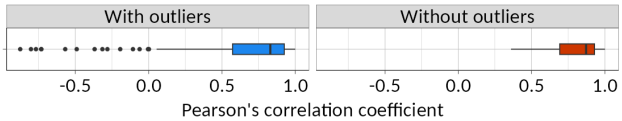

Figure 2. 1.5 IQR rule outlier removal on Movement 10, MCP5 - PIP5.

4. Conclusions and outlook

We presented a novel method for extracting useful data for grasp-oriented hand modelling using noisy sensor measurements. The validity of data was investigated, as well as 116 highly correlated dependency-movement associations identified (median absolute correlation $\geq$ 0.7). The provided identification will serve as a basis for future comprehensive modelling of hand grasps oriented at rehabilitation robotics. In future work, regression modelling is planned with the aim of estimating the corresponding coefficients for all the identified dependency-movement associations. Then, synthesis of all coefficients, using dependency matrix and clustering methods, will be necessary for presenting valid and comprehensive rehabilitation-oriented grasp models, as well as a grasp taxonomy based on similar intra-finger dependencies.

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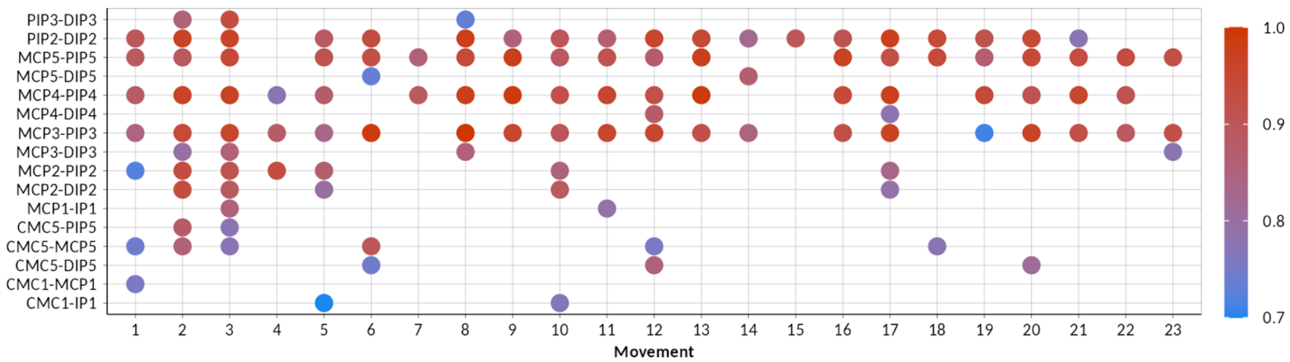

Figure 3. Correlation analysis of intra-finger joint dependency-movement association