Analysis of 3D motion patterns of male and female top-level handball players with Kohonen's Self-Organizing Maps.

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Introduction:
Self-organizing maps as described by Kohonen (1) can be. used as a means for data reduction of high-dimensional data sets with possible underlying relations between the variables. Especially in human motion analysis they are useful because of their non-linear properties and will therefore outperform an analysis with classical PCA. Therefore we used this algorithm for the analysis of 3D data of a standing throw by handball players. We looked for differences between male and female players on a more holistic level in their throwing pattern. Traditional statistical analysis with data from discrete points in time is limited both in the linear approach as in the chance for a type 1 error with many variables.

Materials and Methods:
Three-dimensional coordinates of 11 male and 10 female Swiss handball players were collected with a VICON motion system (7 camera's). These were transformed to Euler/ Cardan angles in Mathcad according to ISB guidelines and angular velocities were calculated. This gave us 25 time series of 50 data points which were linearly normalized to a mean of 0 and a variance of 1 as the SOM uses Euclidean distances and the raw data are differently scaled. A SOM was made based on 1 reference trial of a random male player in the SOM-Toolbox for Matlab (2), and a U-matrix with best-matching unit (BMU) trajectory was generated. The BMU-matrix (50x1) of all trials of all players was exported and used for further quantitative analysis. Mean inter- and intra distance values were calculated with respect to the reference trial as was done by Bauer and Schöllhorn (4).

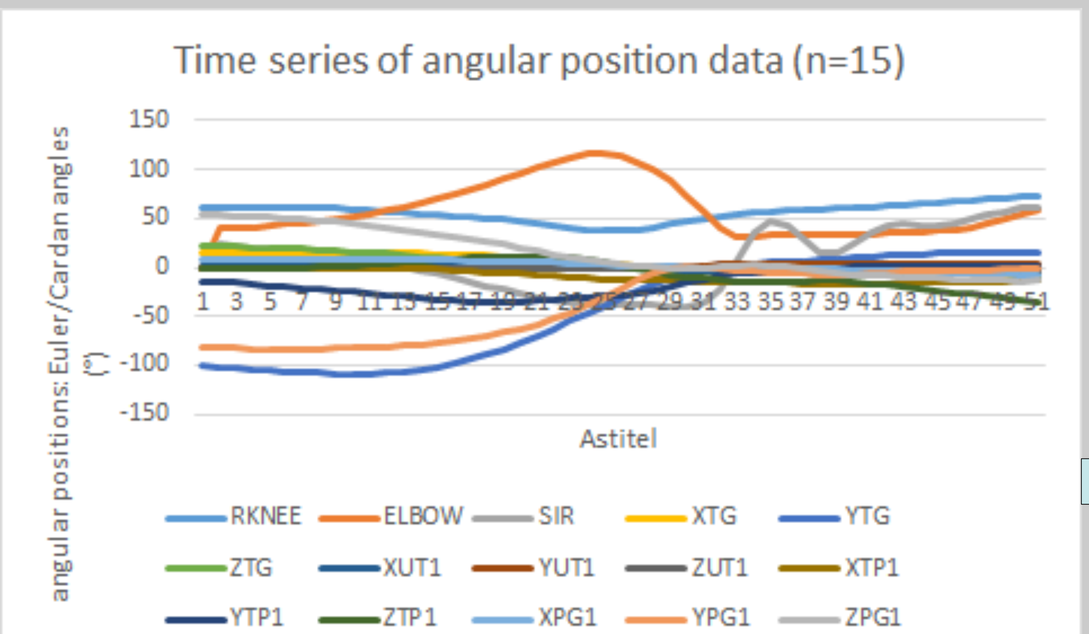

Fig. 1: angular position data
RKNEE = knee angle
ELBOW = elbow angle
SIR = shoulder internal rotation angle
XTG = lateral tilting angle trunk
YTG = longitudinal rotation angle trunk
ZTG = forward tilting angle trunk
XTP = X-factor angle between trunk and upper thorax (frontal plane)
YTP = X-factor angle between trunk and upper thorax (transverse plane)
ZTP = X-factor angle between trunk and upper thorax (sagital plane)
XTP = X-factor angle between trunk and pelvis (frontal plane)
YTP = X-factor angle between trunk and pelvis (transverse plane)
ZTP = X-factor angle between trunk and pelvis (sagital plane)
XPG = lateral tilting angle pelvis
YPG = longitudinal rotation angle pelvis
ZPG = forward tilting angle pelvis

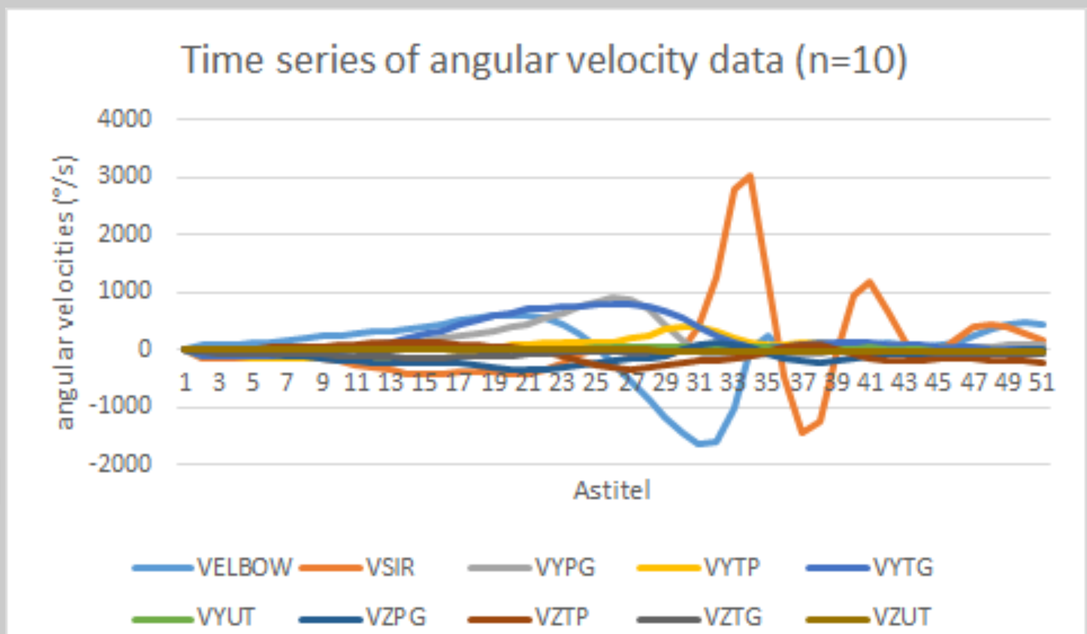

Fig. 2: angular velocity data
VELBOW = elbow extension velocity
VSIR = shoulder internal rotation velocity
VYPG = endorotation velocity pelvis
VYTP = endorotation velocity X-factor trunk-pelvis
VYTG = endorotation velocity trunk
VYUT = endorotation velocity X-factor upper thorax-trunk
VZPG = forward tilting velocity pelvis
VZTP = trunk flexion velocity
VZTG = forward tilting velocity trunk
VZUT = upper thorax flexion velocity

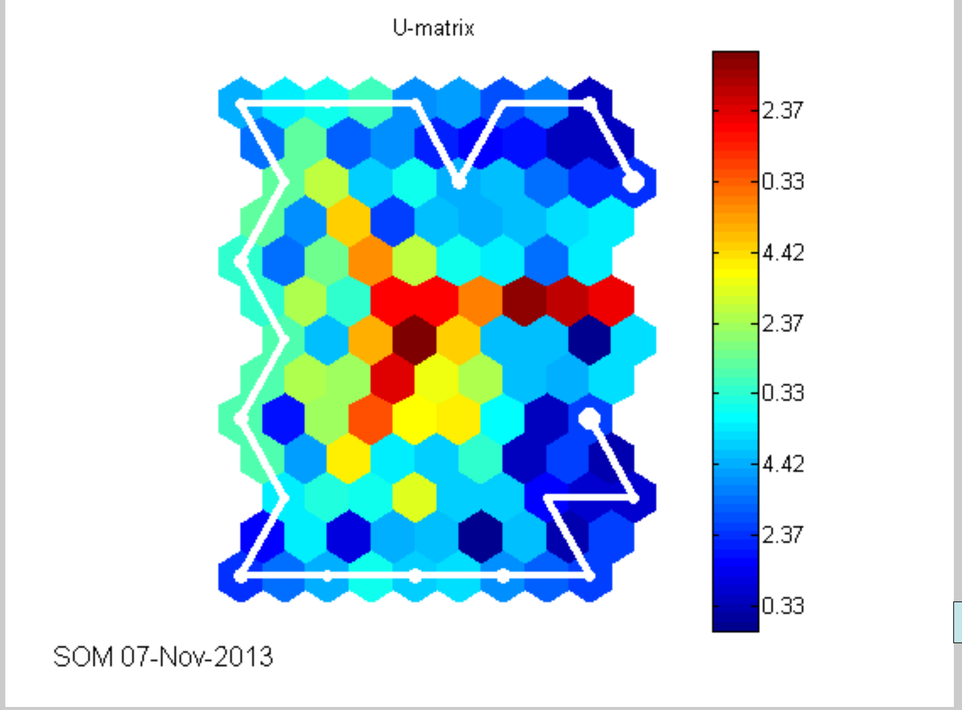

Fig. 3: Unified distance matrix and the trajectory of best-matching units of the trial used as a reference. (male subject)

Discussion and conclusions:
Distance matrix
Mean inter- and intra distance values → ratio (is there a difference between male and female players?) The next step could be to do a cluster analysis to this distance matrix
Mean map quality parameters (QE and TE)?
An interesting approach for a study of the validity of the map would be to use a Monte Carlo simulation with the input parameters of the neural network (initialization, training, learning rate and neighborhood radius) on their effect of the map quality parameters.
Linken aan VDT & Cabri (2012)!!! ☺

Fig. 4: Plot of the distance matrix (red = male players, blue = female players)

References:
(1) Kohonen (2001) Self-organizing maps (3rd Ed) Berlin: Springer-Verslag
(2) Vesanto et al. (2000) The SOM Toolbox for Matlab 5
(3) Bauer and Schöllhorn (1997) Neural Processing Letters
(4) Van den Tillaar & Cabri (2012) Journal of Sports Sciences