Classification of Finger Movement Patterns by Self Organized Maps (SOM)

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In order to obtain movement data of fingers in vivo, we used a three dimensional real time motion analysis system, based on ultrasound (CMS50^{TM}[1]). In the experimental situation we used 4 pairs of markers fixed on the dorsal surface of the metacarpal and on each phalanges. The patients were asked to open and close their fist multiple times. One period (extension - flexion - extension) took about two seconds. Each marker transmitted 25 impulses per second. Using trigonometric analysis the angles in the plain of motion between the individual joints were calculated from the coordinates.
The basic idea of the following data analysis is, to find standard movement patterns, which can be assignd to different lesions in the motion system of the hand. Therefore we measured the index finger of 18 healthy (H) and 6 patients suffering from posttraumatic ulnar nerve palsy (p). Using a computer, we generated sets of data (Fig1), containing the three time dependend angles during extension and flexion, triggered at the first appearence of an angle of 10˚ in the second joint. Thereby we obtained 265 patterns of movement each containing 120 time dependent angles. This datasets were fed to a SOM [2], a neural net made up of 10*10 elements, each representing a movement pattern. The result after the learning process is a map of standard movement patterns (Fig.2) in which every pattern will be labeled either as (h), (p) or empty (o) using testpatterns. Only a few patterns are occupied by both (h) and (p). Further calculation using LVQ [3] show, that up to 95% of independent test patterns not used for the learning process are correctly labeled by the computer.

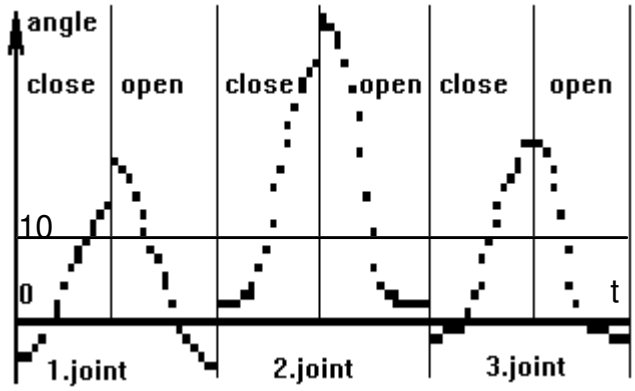

Fig.1: Pattern of movement.
This figure shows the angle over time for different joints. Each short interval lasts 0.8 sec. and was triggered to the first appeareance of the 10˚ angle for the 2. joint. One set of data contains the samples of the angle for each joint during closing and opening of the fist. Open and closing was independently triggered. We collected about 10 samples for each patient.

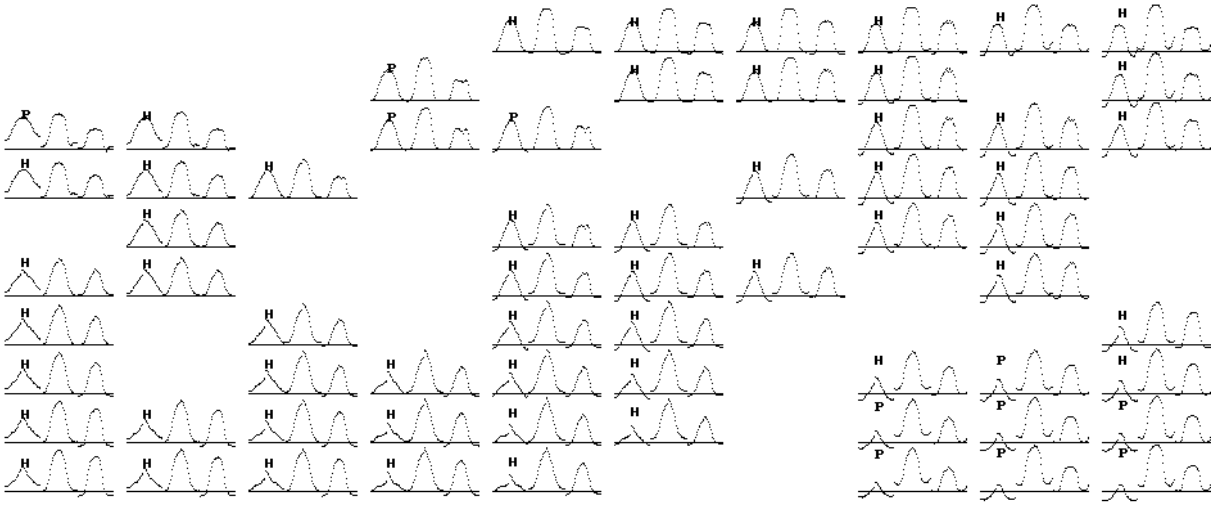

Fig.2: This is a mapping of standard movement patterns. The different patterns were generated by a SOM program. Each pattern was tested with measured patterns and labeled. If it is similar to a movement of a healthy client it is labeled with (H), in case of patients with ulnar nerve palsey with (p), if there was response to each groups we put a (x) and if there was no response we put a (o) at the top.

[1] zebris GmbH Isny, Germany.
[2] Kohonen, T., *The self-organizing map*, Proccedings of the IEEE, 78(9):1464-1480, 1990
[3] Kohonen, T., *LVQ_PAK The Learning Vector Quantization Program Package*, Version3.0 (1.March,1995)