Upper Limb

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TEMPLATE-MATCHING IN THE IDENTIFICATION OF ARM-HAND SKILL PERFORMANCE IN HEALTHY SUBJECTS AND STROKE PATIENTS

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Introduction and Objectives: Objectively assessing actual arm-hand skill performance (AHSP) is very important to evaluate therapy efficacy in patients with neurological disorders. Instruments to identify skills and determine both amount and quality of actual AHSP in daily life are lacking, necessitating the development of a new measure. To identify skills, pattern recognition techniques like statistical classification, neural networks, structural matching and template matching can be used. The aim of this study is to provide proof-of-principle of a method to identify activities based on template-matching, in a healthy participant and a patient with stroke.

Methods: Multiple devices, each containing a tri-axial accelerometer, tri-axial gyroscope and tri-axial magnetometer were attached to the hand, wrist, upper arm and chest of participants, i.e. four devices to the dominant arm-hand and chest of the healthy participants, and seven devices to both arms and hands and the chest of the stroke patient. Thirty healthy individuals and one patient with stroke performed the activities ‘drinking’, ‘eating’ and ‘combing’ 5 times in a standardized manner, i.e. with similar starting position and instruction on how to perform the skill. Signals were filtered with a 4th order zero-time lag low-pass Butterworth filter (cut off freq.: 2.5 Hz). Data analysis consisted of the following steps: 1) temporal delimitation of each of the five activity attempts, i.e. identifying the start and endpoint of each attempt recorded; 2) signal normalization in the time domain to correct for (small) variations due to differences in speed of task execution; 3) averaging signal matrices from the five attempts of each individual person to obtain an individual template, i.e. the underlying ensemble averaged signal matrix per task per individual; averaging signal matrices from the individual templates of the first 29 healthy persons included, to create a generic template, to identify this activity among the signals of the 30th person; 4) identification of dominant sub phases of templates, within a specific task, using Gaussian-based linear envelope decomposition procedures; 5) recognition of specific activity execution among various activities performed daily, i.e. searching for template occurrence among signal recordings gathered in a standardized setting, using feature extraction and pattern recognition algorithms based on 2D convolution. Templates representing a complete activity as well as templates containing sub phases of an activity were used. Cross-correlation coefficients were calculated to quantify goodness-of-fit.

Results: Performance of the activities ‘drinking,’ ‘eating’ and ‘combing’ were recognized with high sensitivity and high specificity in healthy participants for both the generic template and the individual template. Using the individual template, recognition occurred with high correlations (e.g. for the activity drinking a correlation of 0.93 for the template representing the complete activity and for the template containing activity sub phases mean correlations ranged between 0.89 and 0.99). Using the generic template, recognition was similar regarding sensitivity and specificity (i.e. all activity performances were recognized) but correlations were lower (table 1). In the stroke patient performance of the activities drinking, eating and combing were unambiguously recognized using the individual template. For both the template representing the complete activity and the template containing the activity sub phases, correlations with which the activity was recognized were high (table 1). In stroke no generic template was created since only one patient was included.

Conclusion: Proof-of-concept of this method to identify a specific activity among multiple activities performed in a standardized setting was shown for both healthy participants and a stroke patient. The long-term aim is to use this method to a) identify which arm-hand skills are performed during daily life by individuals, b) determine the quantity of skill execution, i.e. amount of use, and c) determine the quality of AHSP. At the moment, as far as we know, no such instrument is available. Future research will focus on: a) optimizing the method described, and b) applying this method for more activities, in more neurological patients and in daily life situations.

Table:

		## of times an activity was:		Correlation:	
		Performed	Recognized	Complete activity	Activity sub phases
Healthy subjects	Drinking	5	5	0.79*	0.78-0.86*
	Eating	5	5	0.58*	0.69-0.80*
	Combing	5	5	0.42*	0.68-0.90*
Stroke patient	Drinking	4	4	0.99	0.81-0.99
	Eating	5	5	0.65	0.81-0.98
	Combing	4	4	0.97	0.60-0.99

*correlation based on a generic template.

Caption: Table 1: Number of performances recognized and mean cross-correlation coefficients during pattern recognition.

Disclosure of Interest: None Declared