Hand Rehabilitation System (HaReS)

- HaReS has been designed for functional and motor rehabilitation of fingers and the wrist in the early stages of recovery.
- It consists of ergonomic wearable sensors (5DT gloves and goniometers) and game-based (Hares game) training environment that provides feedback to the patient.
- Hares game has been designed for a wide group of stroke patients to increase the motivation and support them in performing large number of repetitive movements.
- The cognitive and motor task of the game is to control position of the pad (hat) in such a way that the number of caught objects (hares) is maximized.
- Different scenarios of the game and levels of difficulties are defined by three aspects: the number of objects falling, the position of the objects on the screen (including spatial configuration of the objects), the speed of falling.
- While playing a game, the patient interacts with a virtual universe, which receives player’s responds and control inputs (hand movements) by changing its status. Information regarding the outcome of the interaction is then conveyed to player (i.e. scoring), and eventually gathered and used by him/her to decide what to do next.
- A set of reference motor tasks is specified and used in game control, i.e. wrist extension/flexion causes pad movement to the left/right.
- The key element of the system is Surface Electrode Array Stimulation based control of hand and fingers movement, which can provide assistive stimulation to a patient performing a task with impaired hand.

References


Conclusions and Future Work

A novel method of finding the most effective stimulation patterns for multi-channel stimulation has been developed to enable the participant to perform predefined hand gestures. The algorithm is currently being extended to the adaptive approach with different models of $g(u)$. After evaluation on both unimpaired as well as stroke participants, the best approach will be incorporated into the final version of HaReS and the effectiveness of the system will be tested in clinical rehabilitation trials.

Common stroke consequences affecting hand function are: paralysis, finger extension deficit, muscle weakness, over activity of flexor muscles and spasticity.

Successful rehabilitation consists of performing large numbers of high-intensity, repetitive motions.

Main difficulties in stroke rehabilitation:

- Most of stroke patients can hardly move
- Traditional therapies are expensive and difficult to manage due to limited amount of resources compared to the number of patients
- Study indicates that only 31 % of patients actually perform exercises as recommended by therapists.

There is a pressing need for developing novel, mobile solutions.

Successful rehabilitation muscles and spasticity.

paralysis, finger extension deficit, muscle weakness, over activity of flexor muscles.

Common stroke consequences affecting hand function are:

- Such systems should be: non-invasive, easy to use, motivating and interactive and with simple and clear feedback to the patient.
- Enabling home-based hand rehabilitation systems, motivating for patients may reduce costs and increase intensity and effectiveness of therapy.

Hares game has been designed for a wide group of stroke patients to increase the motivation and support them in performing large number of repetitive movements.

The method utilises the concept of Virtual Elements (VE) with a constrained optimisation approach for multi-channel SEAS to find stimulation patterns and pulse-width values which produce the required posture, $y_d$. These can be expressed as in [2]:

$$
\text{minimize } f(u), f(u) = \|y_d - g(u)\|^2
$$

subject to constraints on $u$ required to ensure that the experimentally applied stimulation $u_i$ is practically achievable given the limited number of stimulation levels available. This necessitates that:

$$
u_i \in U_n, \quad 0 \leq u_{n,i} \leq 300, \quad j = 1, 2, \ldots, n
$$

where $U_n$ is a set with $n$ non-zero distinct elements with $U_{n,j}$ the $j$th element. Here $n$ is the number of channels supported by the hardware and the function $g(u)$ is identified during experiment.

Virtual Elements emulate single array element and can be defined by the number of single elements of electrode array and their spatial configuration. VE-based method of finding best stimulation patterns can be more effective and practical for wide group of patients.

Appropriately selected VEs can increase the practical level of selectivity and accuracy of the stimulation.