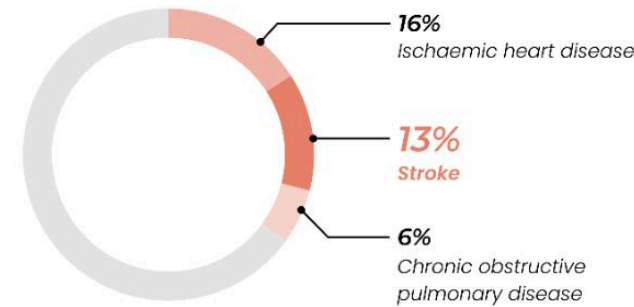
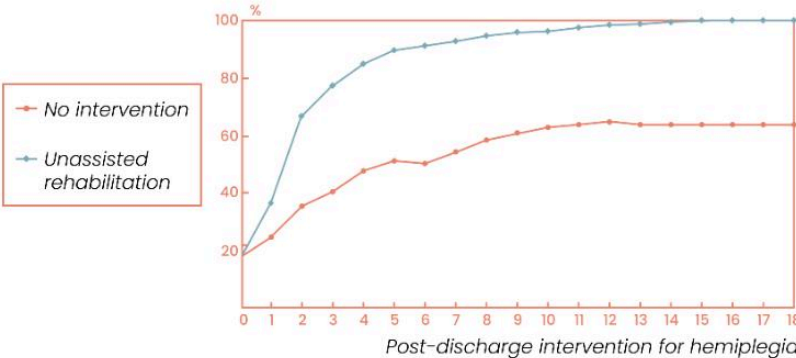


Project Background

Stroke is the 2nd leading causes of death, responsible for approximately 11% of total deaths respectively. **Up to 60% of stroke survivors suffer from upper extremity impairments.**



Stroke survivors continue to recover at home after inpatient rehabilitation ends. Progression may plateau without constant engagement in treatment.



Rehabilitation challenges faced by patients with hemiplegia

The restoration of distal motor function

The functional improvement of upper extremities primarily depends on the hand function. However, in the recovery process from upper extremity hemiplegia, **the restoration of distal motor function comes later and is more strenuous than the restoration of proximal motor function.**



Cognitive dysfunction

Cognitive impairment as evaluated with a comprehensive neuropsychological assessment is prevalent in stroke survivors even with successful clinical recovery. **Typically multiple domains and complex cognitive abilities are affected.**

A decreased mental state

Anxiety is a common psychological problem after stroke. Anxiety disorders or symptoms can also compromise rehabilitation; thus, **the significance of patients' psychological status after stroke forms an essential element of their treatment process.**

User Research and Interview

Huilan Zhou
Stroke Survivor

I feel:
Training is a heavy burden.

I want to:
Get rid of cumbersome training to return to normal life.

Changming Xu
Chief Physician, Renji Hospital

Patients feel:
Bored and painful in training.

Patients are:
Unwilling to carry out locomotor activities.

Q Do patients after stroke have to undergo rehabilitation? Must be treated in hospital?

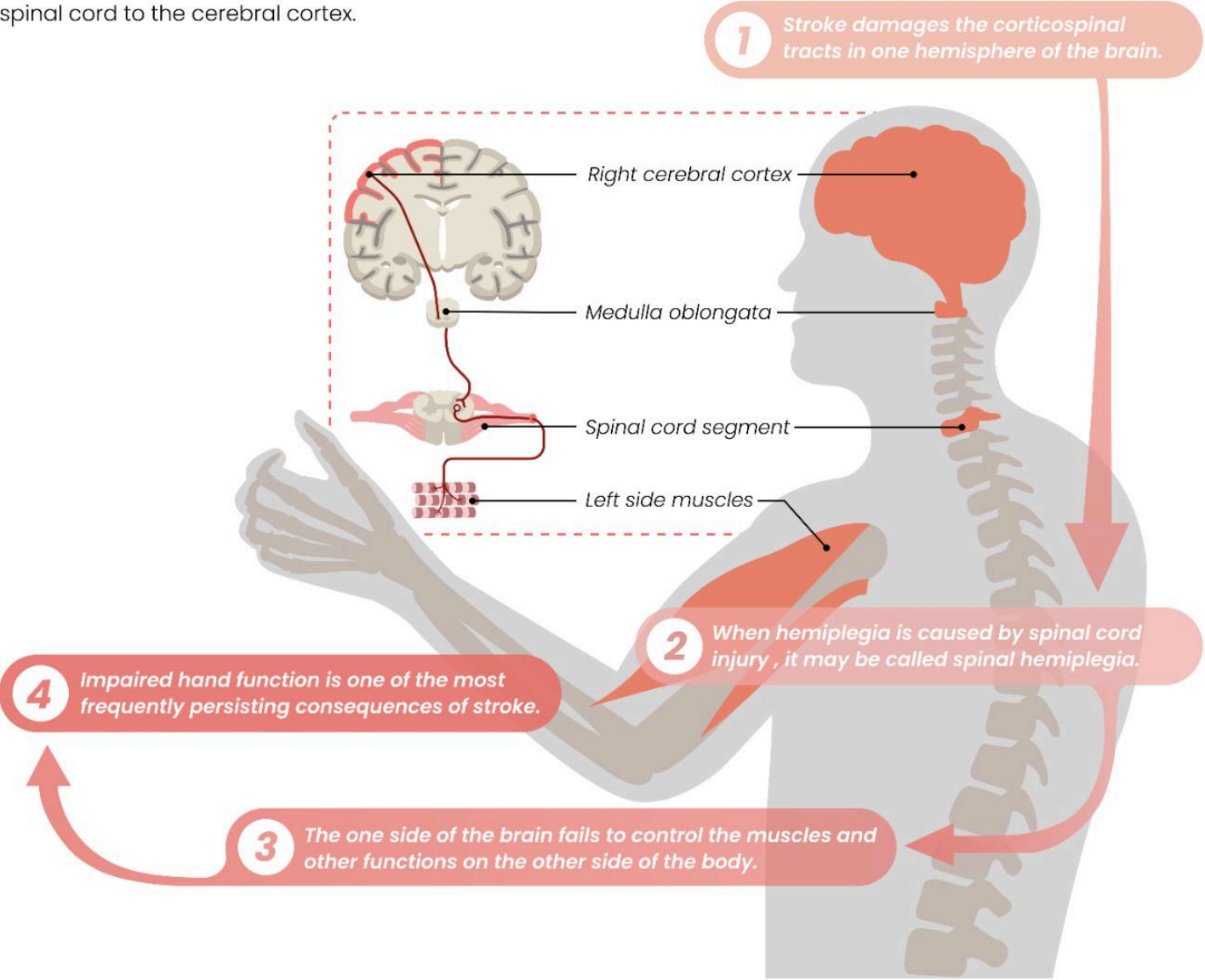
The post-stroke functional symptoms **will not gradually recover voluntarily. It's impossible to stay in the hospital for a long time** for rehabilitation after a stroke, so it's necessary to return home for rehabilitation.

Q Whether patients after stroke can fully recover to normal through rehabilitation training?

There is no way to fully restore the functional impairment after a stroke. Hard work in rehabilitation training can improve it, but **it will get worse if patient don't work hard.**

Introduction of Hemiplegic Pathology

Hemiplegia is the paralysis of the muscles on one side of the body. The most common cause is stroke, which damages the corticospinal tracts in one hemisphere of the brain which extend from the lower spinal cord to the cerebral cortex.



Insight

Camera-based Systems

This method can be accurate but **involve privacy issues**. Also, **the environment cannot be too cluttered**, to avoid skeleton merging.

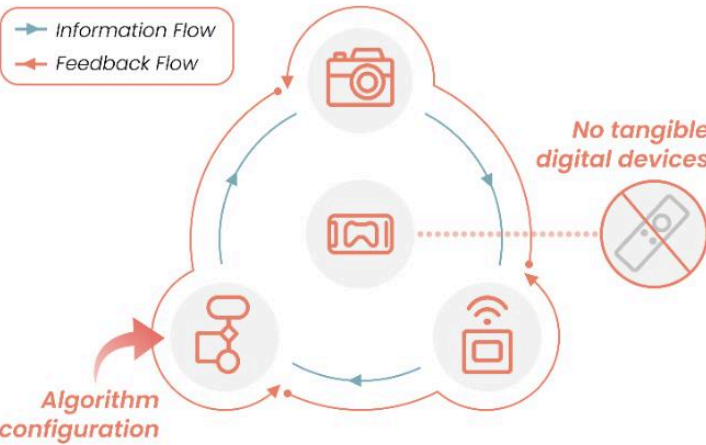
Tangible-interaction-objects-based System

These systems can **reduce a learning times**. However, they are generally **limited to a single training mode and have poor scalability**.

Wearable-sensor-based System

EMG sensors have been widely utilized for rehabilitation systems. However, **classification accuracy for stroke patients is typically much lower** than that of healthy individuals.

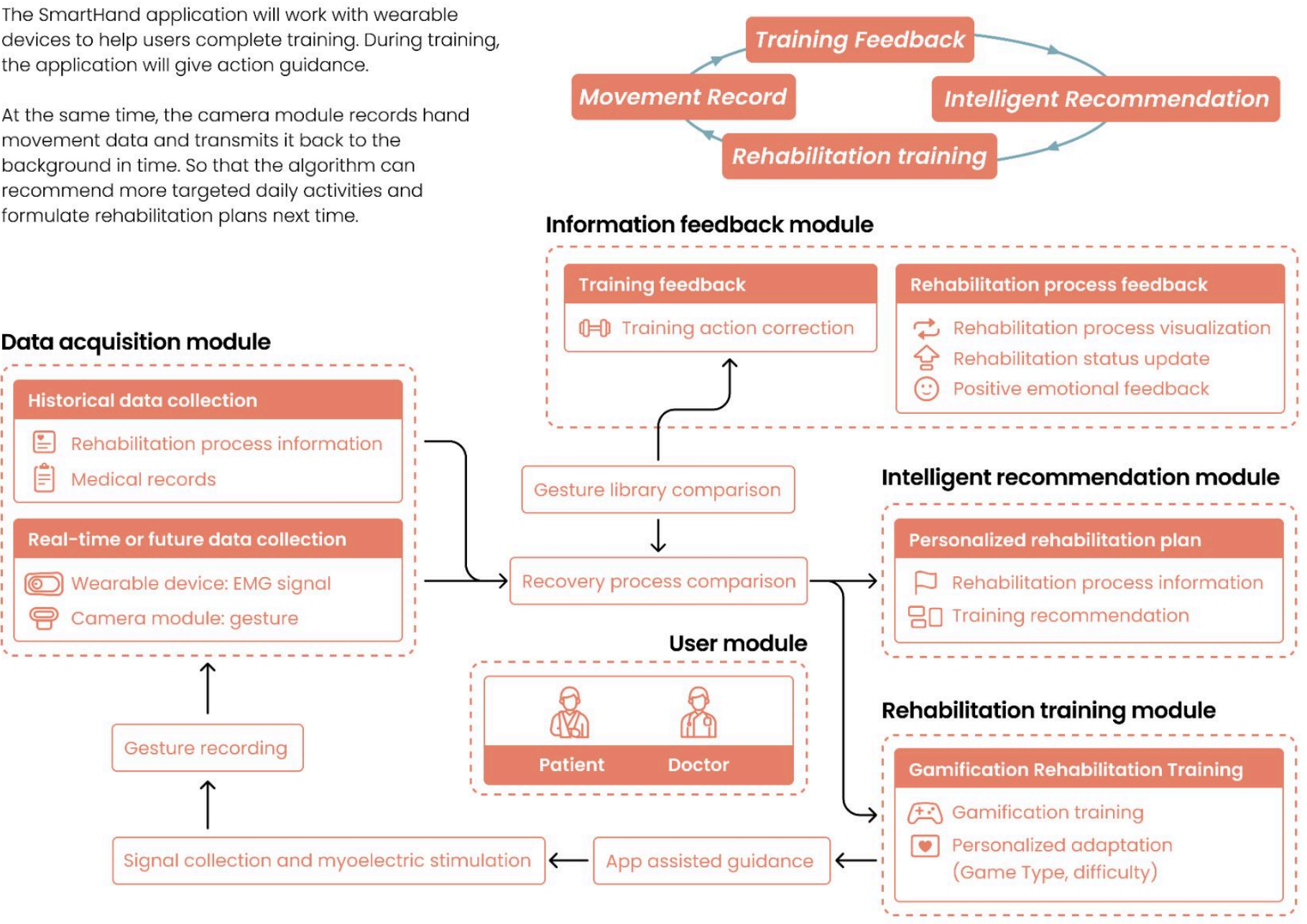
We hypothesized that the proposed sensing and algorithm configuration could detect stroke patient hand gestures during the cognitive and motor tasks required in the serious games.



System Design

The SmartHand application will work with wearable devices to help users complete training. During training, the application will give action guidance.

At the same time, the camera module records hand movement data and transmits it back to the background in time. So that the algorithm can recommend more targeted daily activities and formulate rehabilitation plans next time.

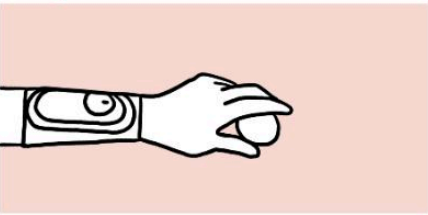


Current Rehabilitation

Stage	1-3 months	3-6 months	6 months - 5 years or longer
	Soft paralysis period No voluntary movement of the hand, muscle atrophy.	Cramping period The condition is stable, the best period of rehabilitation.	Recovery period The condition is stable, the best period of rehabilitation.
Sequence of rehabilitation			
Action	Acute phase: Patients are manic	Patients tend to give up	Upper limb functions recover much slower
	Depressed and fatigue Feel life meaningless	Acute phase: Patients are manic	Losing confidence in training Recording daily small progress can maintain a positive attitude
Point	As time goes on, the speed of rehabilitation slows down and it is more difficult to persist.		

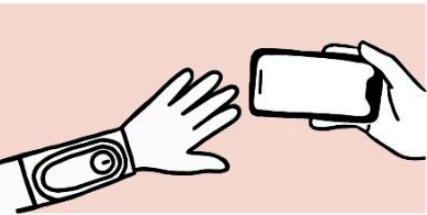
Storyboard

Daily time



Help users to complete hand movements through electrical stimulation.

Training time



Provide users interesting games, guide them to complete their training. Users would qualitatively be more enthusiastic about training.

After

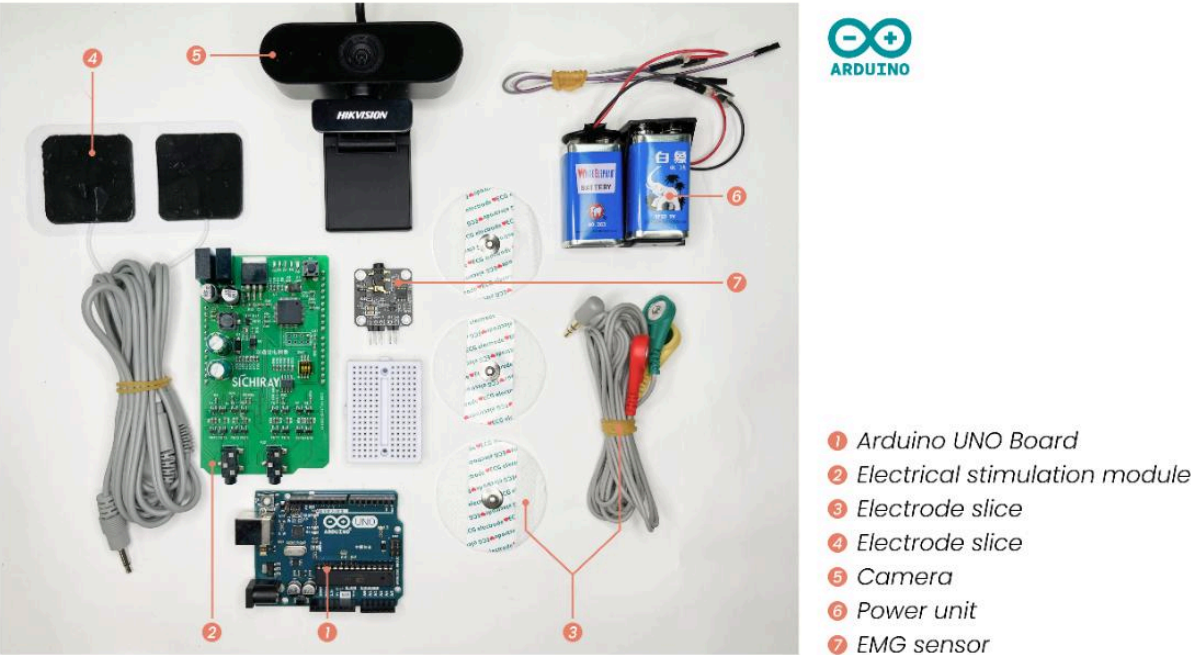


Give users feedback about their recovery process. Regularly communicate with the doctor to update the rehabilitation plan.

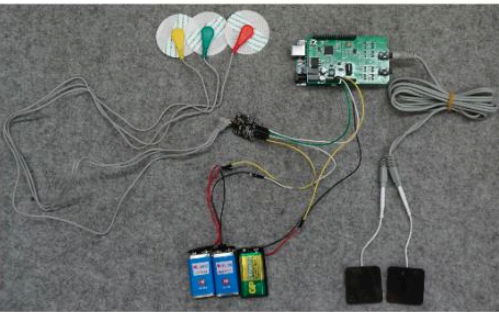
Technical Research

Hardware

EMG detection and electrical stimulation **are controlled through Arduino-based electrical stimulation module**. The camera module is used to record gestures.

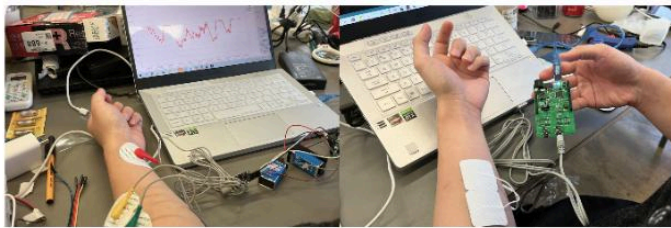


Assembly and Functional Principles



EMG signals detection

The EMG sensor **detects the myoelectric signal**, and outputs EMS to **promote the muscle contraction**.

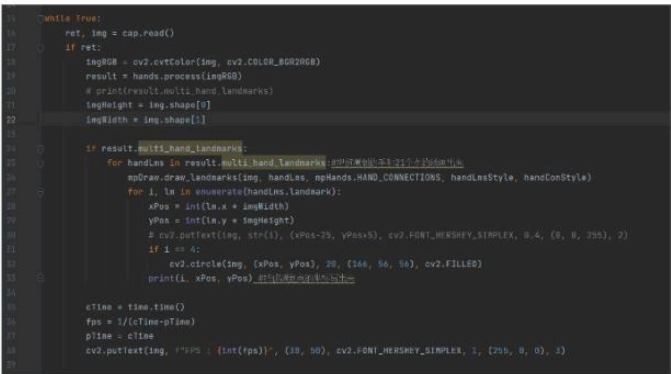


EMG signals detection

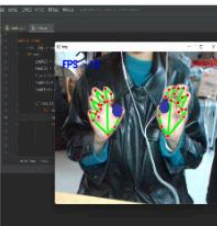
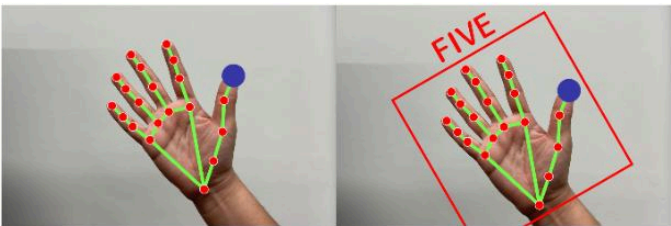
Apply electrical stimulation

Software and Coding

We use the Python-based MediaPipe to **recognize gestures and compare them with standard gestures in the gesture library**. It is converted into data by an algorithm, and the data is transmitted to the host.



Coding



Test

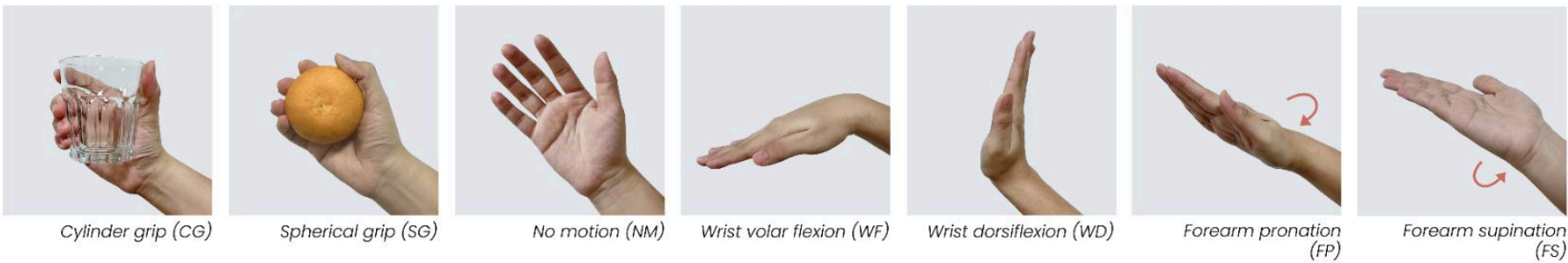
Work Flow of Gesture Recognition

Template matching requires **the establishment of a basic gesture library** to compare the accuracy of patient hand movements.

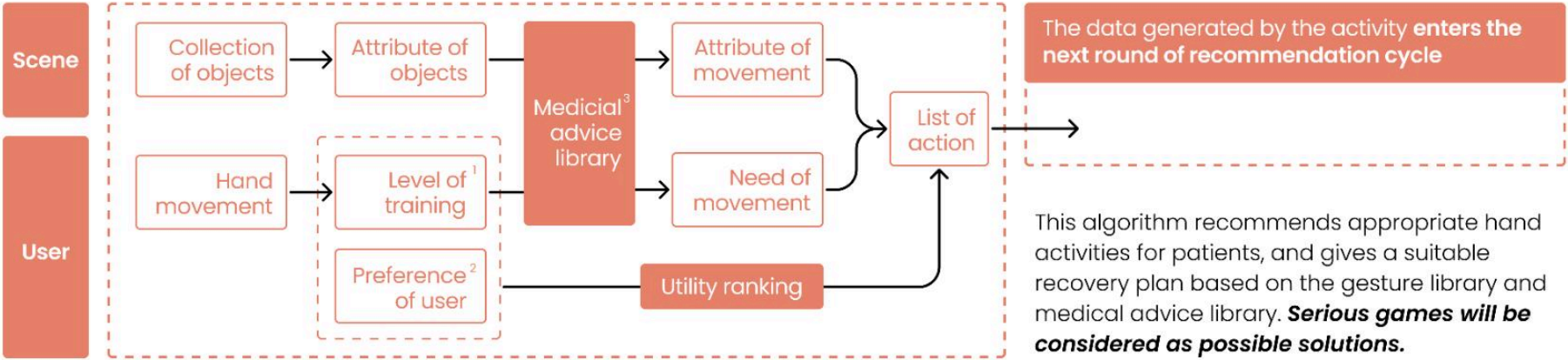


Gesture Library

The FMA is an effective and detailed evaluation tool for assessing motor function after stroke. 11 upper extremity fine movements are selected from the FMA and are suitable for motor function rehabilitation. The movements include hand, wrist and forearm movements.



Movements Generation Algorithm Framework



¹ Level of training

Assessed in the number of hand movements obtained by the vision module

² Preference of user

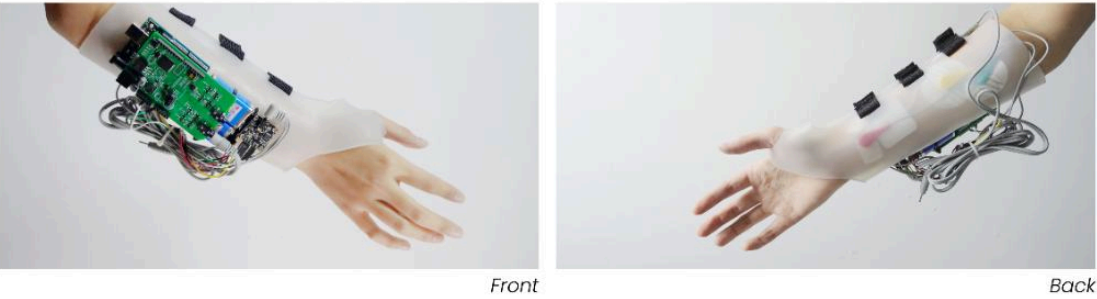
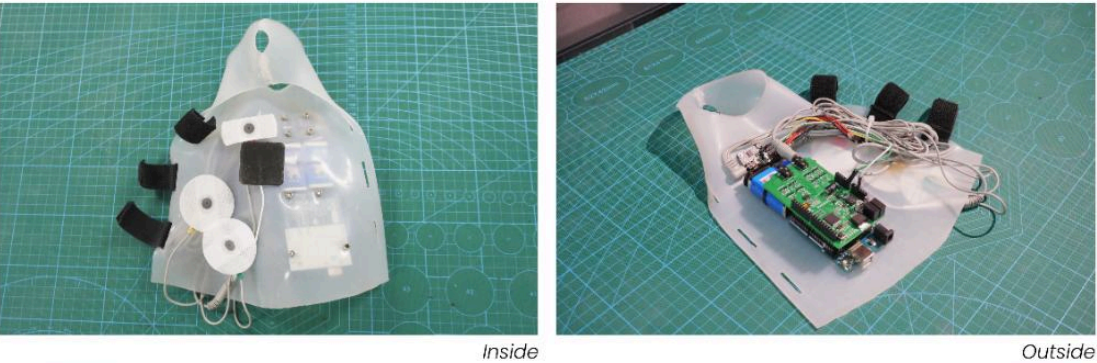
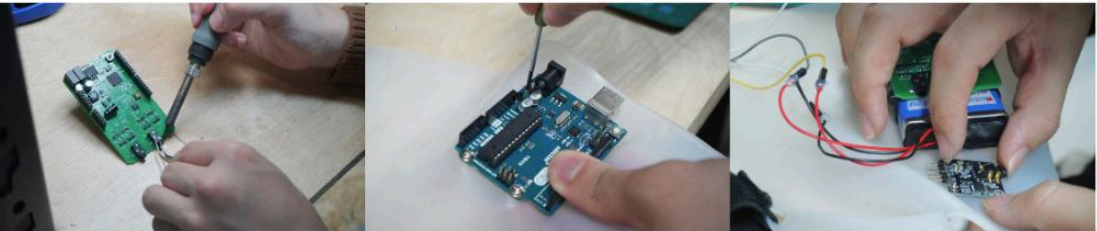
Calculation of clicks from user training records and activity recommendation lists

³ Medical advice library

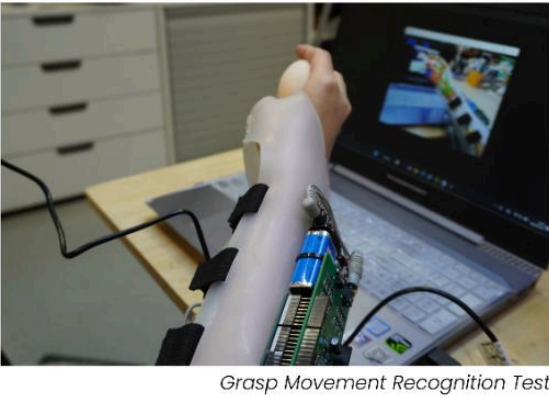
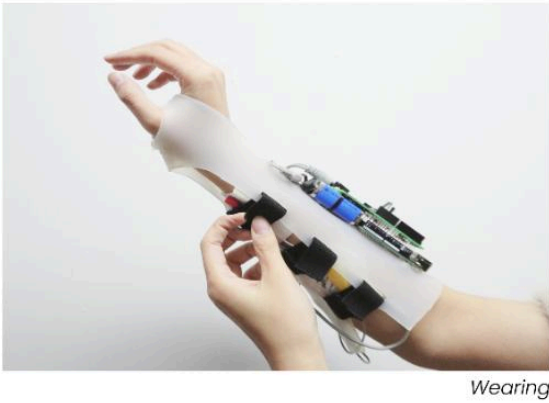
Define the action requirements such as muscle training and action intensity corresponding to the training level

■ Prototyping and Test

Silicone Casting and Component Assembling

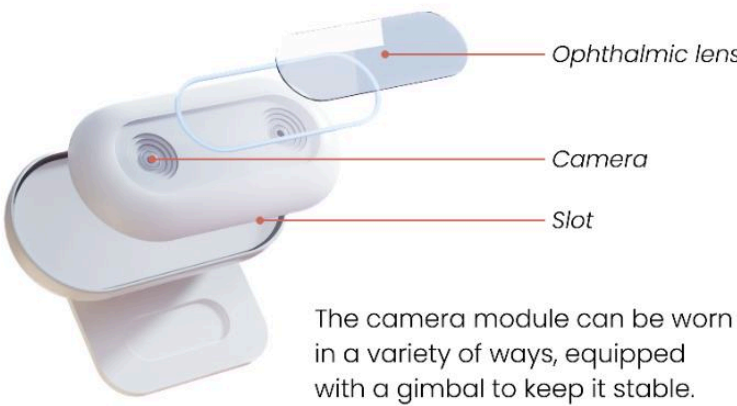


Functional Model Test



■ Product Design

Camera Module

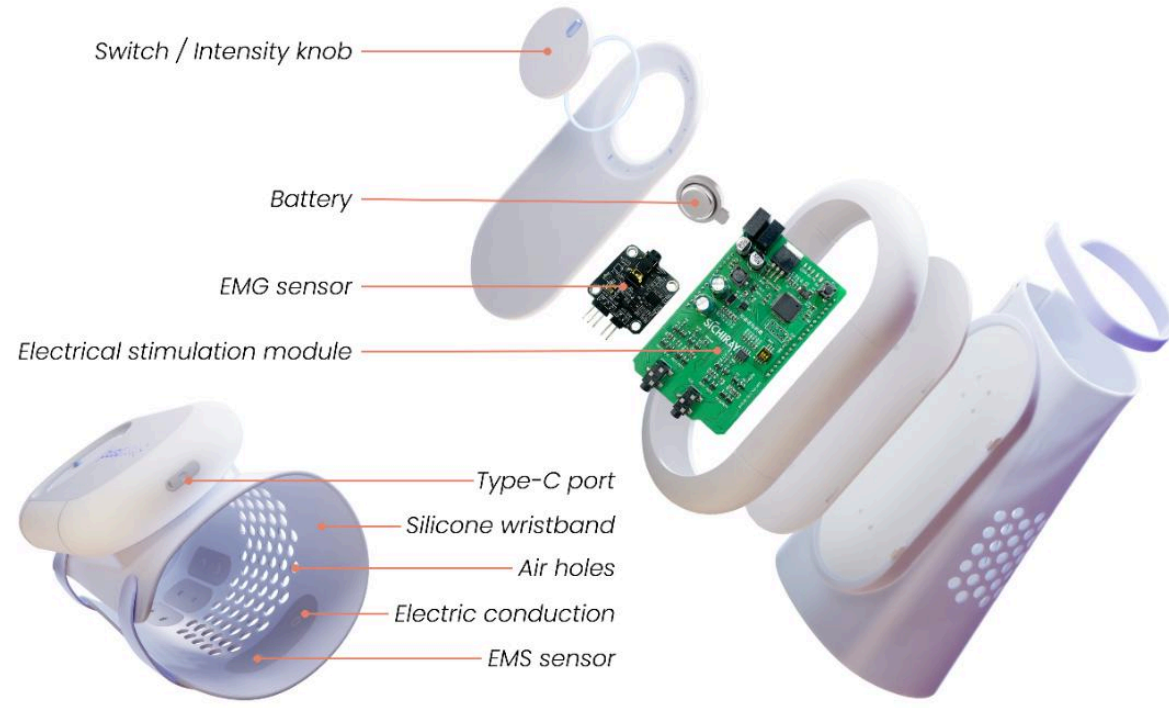
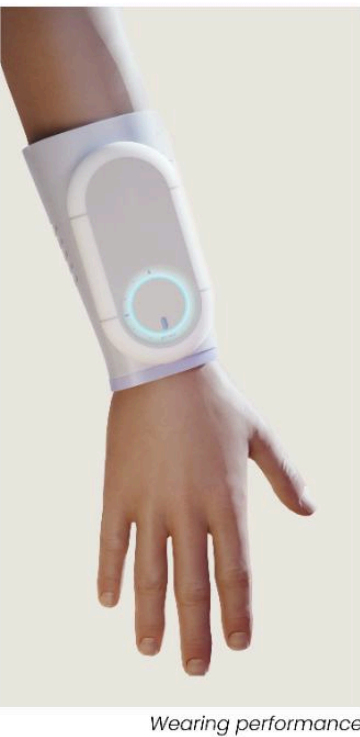


Wearable Module



A switch on the top of the device can be rotated to control the intensity of electrical stimulation.

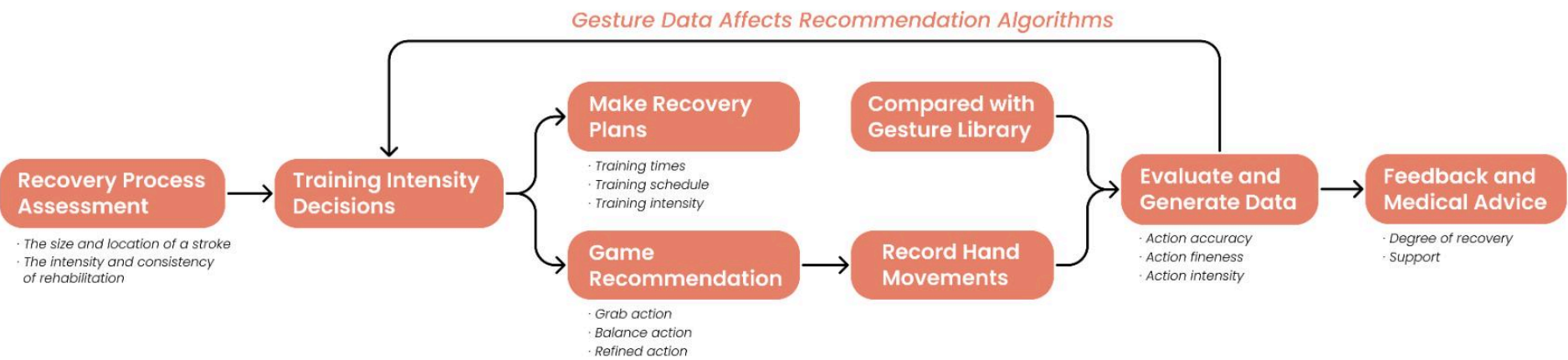
The soft wrist strap wraps the arm to prevent slipping, and the magnetic buckle adjusts the tightness. **The integrated electrodes containing hydrogel patches on the inside of the wristband conduct bidirectional current conduction.**



Interaction

How SmartHand helps people recover from hemiplegia?

SmartHand supports daily supplementary training through App. The algorithm builds a dynamic healing process for the user based on the data. **App can give training recommendations and guidance, record and analyze data, and develop personalized training plans.**



Architecture Diagram

The App assists patients in rehabilitation in the form of games. In addition to the game section, the App can view the rehabilitation progress and achievement wall to get the latest training plan and medical advice.



Interaction Prototype



Rehabilitation tasks



User Profile

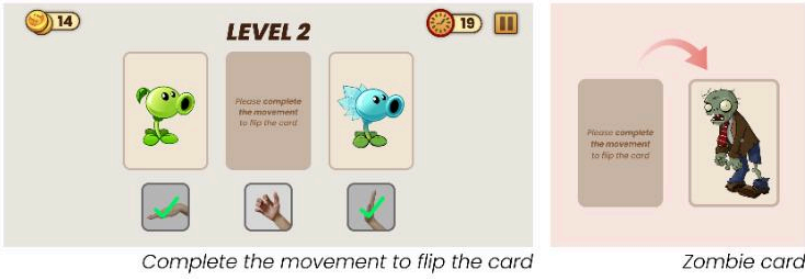
Serious Games

Two serious games were developed based on movement estimation. The games provide visual and audio feedback to the patients.

	Find the Zombie			Happy Salesman		
Group 1	MF	O	WD	TA	SG	FP
Group 2	ME	CG	WF	CG	FP	FS
Group 3	TA	SG	FP	HG	O	FS
Group 4	HG	NM	FS			

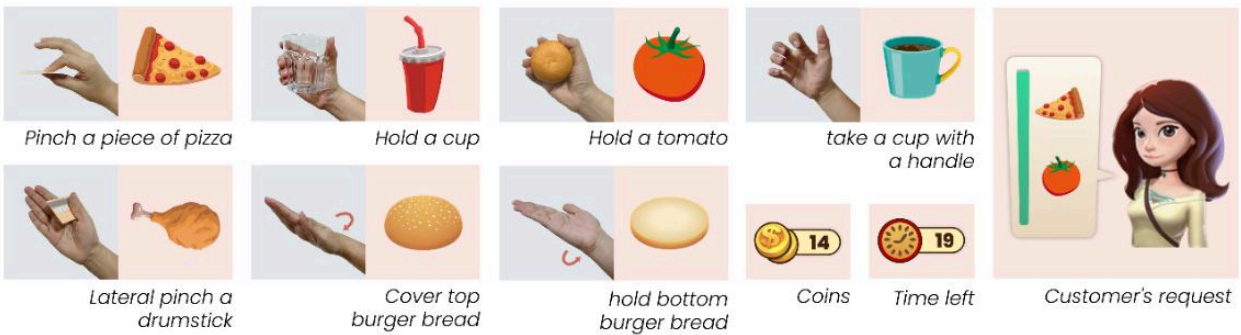
Patients select the correct target in the serious game and perform the corresponding movement. The game “**Find the Zombie**” was designed for both motor and cognitive function training. The game “**Happy Salesman**” was designed to train motor function and improve performance in ADLs.

Game 1: Find the Zombie



In this game, three cards appeared with a Zombie and two Plants on the front. Then, all cards were flipped over and randomly swapped positions. **The patient was required to find which card is the one with the Zombie and perform the corresponding hand movement shown below that card.**

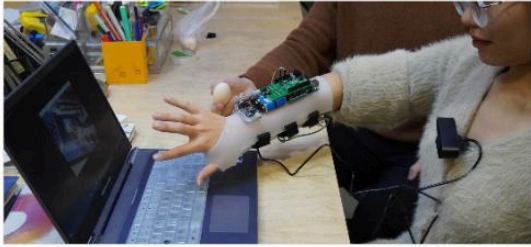
Game 2: Happy Salesman



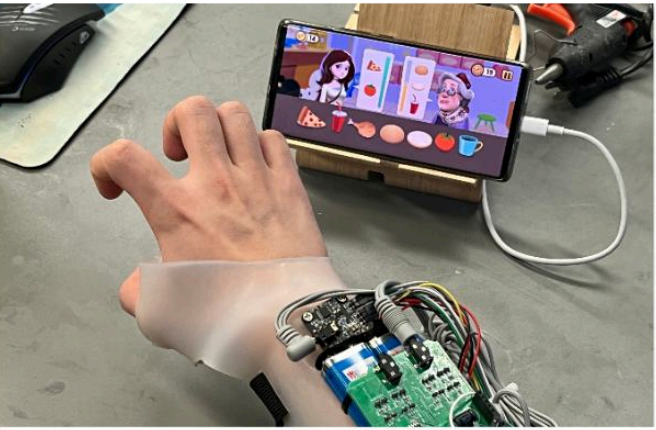
Pass the right food to the customers



Level score



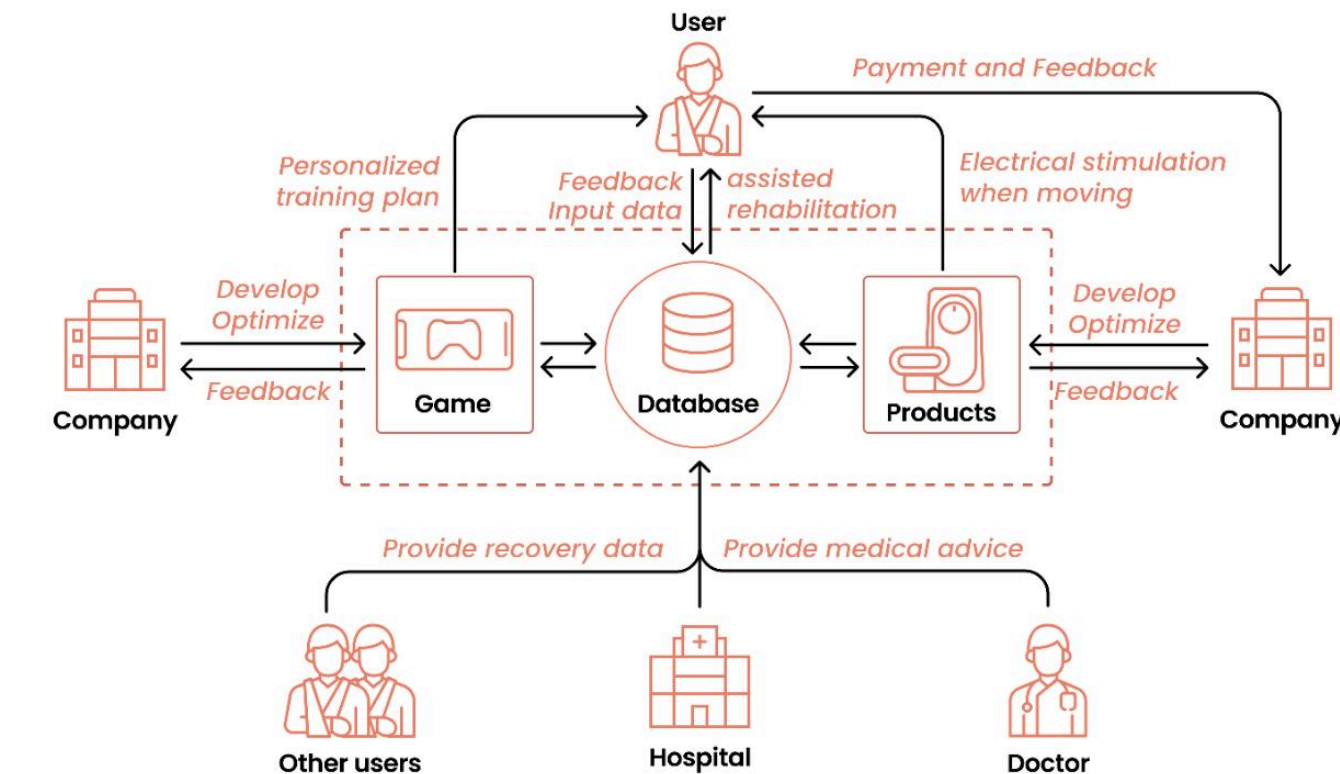
Daily use scene



Game testing

Service System Mapping

SmartHand is equipped with a database developed by professional companies. User recovery data and professional medical advice can be uploaded to the database for users and hospitals. **SmartHand has the function of continuous learning, calls the database in real time and dynamically adjusts rehabilitation plan.**



Telemedicine to support recovery

Telemedicine can effectively solve the problem of shortage of medical resources. For long-term recovering patients, in-person medical care is often unnecessary. **Telemedicine improves efficiency and saves costs.**

Data transfer and sharing between users

Build a user-centric database which data comes from doctors and users. **The continuous learning of the algorithm is realized. Integrating usage information from others will improve the effect of rehabilitation.**

Service Blueprint

