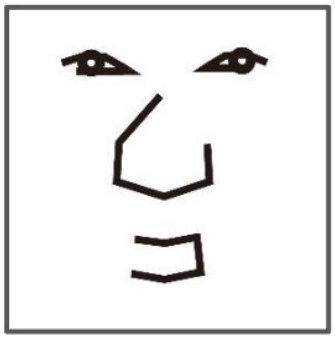
FaceSwitch:



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An AI-Powered Switch App to Support Communication for People with Severe Motor and Neurological Disabilities

Summary: People with severe physical and neurological disabilities face significant challenges in communication and environmental control. To address these issues, we have developed "FaceSwitch," an iOS/iPadOS-based app that utilizes AI-driven facial motion recognition to enable intuitive, non-contact switch input. By detecting and analyzing facial movements via the device's camera, the system allows users to perform various operations such as calling for help, making selections, or controlling household appliances. This paper outlines the technical features and benefits of FaceSwitch, presents case studies highlighting its practical use, and discusses its potential for wider implementation in clinical, educational, and home settings.

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People with severe motor or neurological impairments face significant challenges in communication and environmental control. For these people, the ability to utilize even a minimal amount of residual physical movement to establish stable means of communication is of critical importance. Existing assistive technologies—such as physical switches and eye-tracking systems—have been introduced to support such needs. However, these devices often present issues such as high cost, difficulty of operation, and challenges in achieving appropriate physical fitting.

To address these issues, we have developed FaceSwitch, an app for iOS and iPadOS platforms designed to provide an intuitive and simplified interface using AI. This application detects movements of the user's face using the device camera to function as switch input. For example, one user may configure the system to recognize mouth opening, another may define a three-second eye closure, and another may assign a combination of closing the eyes and turning the head to the right—all as valid switch gestures.

Moreover, FaceSwitch incorporates automatic face-tracking functionality that continuously follows the user's face, even when involuntary movements occur or the user's body position changes while lying in bed. As a result, high-level fitting skills are not required, and the system flexibly adapts to different environments. This enables users with severe motor or neurological disabilities to perform communication and environmental control based on their available functions.

This paper outlines the technical features and advantages of FaceSwitch and examines its usefulness, current challenges, and prospects through actual use cases.

ANTICIPATED AREAS OF APPLICATION

The intended use of this app extends beyond the medical and welfare sectors to include educational contexts, especially within special needs education. Teachers can use the app to observe students' voluntary responses and identify potential pathways for communication. If future versions include the capability to measure and record the frequency of responses—such as the number of times a child closes their eyes—it could serve as a valuable assessment tool for quantitatively evaluating expressive intent.

FaceSwitch may also prove beneficial for professionals such as Assistive Technology Specialists, Occupational Therapists (OTs), and Speech-Language Pathologists (SLPs). It can assist with assessments and the creation of personalized intervention plans by providing quantitative behavioral indicators. This is particularly useful in pediatric rehabilitation or for people with progressive conditions, where determining the presence and consistency of voluntary movements can help guide interface selection and support strategies.

At present, features such as automatic recording of response frequency and improved recognition accuracy for users wearing respiratory equipment remain under development. This paper discusses the practical implementation potential based on current capabilities and outlines the direction of future technological enhancements.

CHALLENGES FACED BY PEOPLE WITH SEVERE DISABILITIES

People with severe motor and neurological disabilities encounter a wide range of difficulties in daily life. In particular, limitations in speech and fine motor skills often result in significant barriers to both verbal and non-verbal communication. As a result, mutual interaction with others becomes difficult, and their wishes or intentions often go unrecognized or misunderstood in everyday contexts.

This difficulty in communication is especially critical in emergency situations or when assistance is required, as affected individuals often lack the means to call for help independently. Consequently, many are forced into passive lifestyles, having to wait until a caregiver or family member checks on them periodically.

Additionally, operating everyday technologies—such as televisions, lighting, personal computers, or tablets—can be extremely challenging. Although a variety of assistive input devices are available, these may not be compatible with the user's residual motor abilities or may become unusable as the condition progresses. For people with severely diminished muscle strength, even pressing a switch may be physically impossible. Conversely, people with frequent involuntary movements may find it difficult to perform intentional actions accurately due to overlapping motions.

Despite these limitations, many people possess a strong desire to express their thoughts and feelings. The absence of a reliable means to do so severely hinders communication, leading to psychological frustration and a growing sense of isolation.

These issues are not solely dependent on the type or severity of disability; they are also influenced by external factors such as the availability of support systems, human and material resources, and the overall living environment. For this reason, personalized and flexible approaches to support—both in technology and environment—are essential.

Furthermore, caregivers and family members often expend significant time and effort trying to interpret the user's intentions. Persistent communication difficulties can lead to physical and emotional exhaustion, which in turn affects the quality and sustainability of care. Therefore, there is an urgent need for assistive technologies that can respond not only to the direct needs of the user but also help reduce the burden on caregivers and family support networks.

TECHNICAL FEATURES AND BENEFITS OF FACESWITCH

CHALLENGES OF USING TRADITIONAL SWITCH DEVICES

To support communication and environmental control, people with disabilities must be matched with appropriate switch input devices. However, traditional switches often present several limitations.

First, selecting the right device and ensuring it fits properly can be difficult. For example, people with neuromuscular conditions such as muscular dystrophy or ALS may require switches that respond to extremely light pressure or sensor-based inputs. Still, it can be challenging for many users or caregivers to determine the correct switch and position it effectively. In the case of people with cerebral palsy, involuntary movements may shift their body or limbs, misaligning the switch and resulting in poor operability.

Wearable switch devices may also cause discomfort. For users with sensitive skin, attaching sensor pads to the body can be burdensome, and sensors may shift during use. In response to these issues, we developed the FaceSwitch application, which applies facial tracking using AI to enable non-contact, gesture-based switch input.

UTILIZATION OF FACIAL TRACKING TECHNOLOGY

Recent advances in AI have made it possible to detect facial movements accurately using the built-in camera of smartphones and tablets. FaceSwitch leverages this technology to allow facial movements to serve as input triggers, enabling intuitive and accessible operation.

While modern smartphones include accessibility features for controlling screens via facial movements, these systems typically assume the device will be positioned directly in front of the user and are supposed to conduct on-screen tasks. In contrast, FaceSwitch is designed to be used in medical and educational environments where users may not rely on visual interfaces—for example, when using a nurse call system or giving a quick yes/no answer.

A key design priority was ensuring that FaceSwitch could flexibly adapt to the user's environment. Unlike traditional physical switches, which require precise placement, FaceSwitch remains responsive even when the user changes body position. Cameras can also be installed at a distance, such as on a wall or ceiling, without obstructing the caregivers' work.

The app uses Apple's facial recognition technology to extract non-contact coordinate data from facial landmarks (eyes, mouth, nose, etc.) using iPhone or iPad cameras. These data points are used to detect movements, allowing the system to capture even subtle facial gestures with precision.

Smartphones by Apple and Google increasingly support gesture-based accessibility features. For example, Android devices include the "Camera Switches" function under the "Switch Access" settings, which allows users to perform actions by blinking or turning their head. While these features are similar to those of FaceSwitch, they are typically aimed at screen-based control

Functions of FaceSwitch

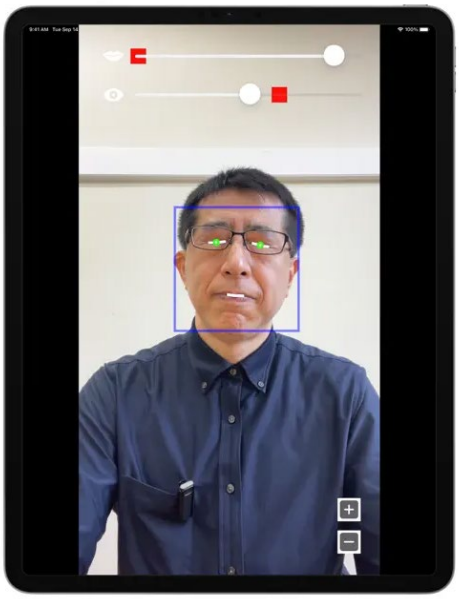
Open the mouth and switch on / off

口を開けると スイッチオン・オフ

Open the mouth and switch on/off.

Close your eyesand switch on / off

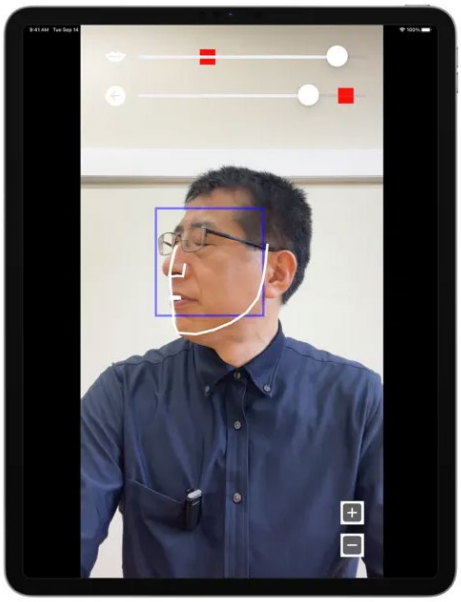
目を閉じると スイッチオン・オフ



Close your eyes and switch on/off.

Turn your head and switch on / off

首を指定した方向に振ると スイッチオン・オフ



Turn your head and switch on/off.

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and are not optimized for users with significant cognitive or motor impairments. In contrast, FaceSwitch is designed to be more universally usable, including for simpler purposes that do not require looking at the screen, such as nurse calls.

SWITCH INPUT FUNCTIONS OF FACESWITCH

FaceSwitch enables users to intuitively and easily operate devices by converting facial movements into switch inputs. The current version of the app supports the following eight facial gestures, (See Functions of FaceSwitch) which can each be configured to output a switch signal:

- Open mouth
- Close mouth
- Turn face right
- Turn face left
- Turn face up
- Turn face down
- Open eyes
- Close eyes

In the update scheduled for release in June 2025, eight additional facial gestures will be supported:

- Look right
- Look left
- Look up
- Lift eyebrows
- Lift mouth corners (smile)
- Pucker lips
- Bite/thin lower lip
- Stick out tongue

YouTube Video - Switch control through facial recognition.
https://www.youtube.com/shorts/Mg-8pbcAOPE

To help reduce false inputs, FaceSwitch includes a setting that allows users to specify the duration a gesture must be maintained before it is recognized. For instance, a user can set the app to ignore short eye blinks by requiring that the eyes remain closed for a longer duration before the action is recognized.

These facial gestures can be used not only to trigger a nurse call or control environmental systems, but also to operate AAC (Augmentative and Alternative Communication) devices and household appliances. For example, in conjunction with a Bluetooth relay device, a user could open their mouth to initiate speech output, turn their head to the right or left to navigate between options, and close their eyes to make a selection.

Environmental control features include the ability to operate lighting and televisions, and when used together with the battery-powered MaBeee switch, users can also control various devices that run on batteries.

Additionally, FaceSwitch can play sounds or synthesized speech during operation, making it possible to produce a nurse call chime or simple messages such as "Yes" or "No," without operating another app or device.

OPERATION

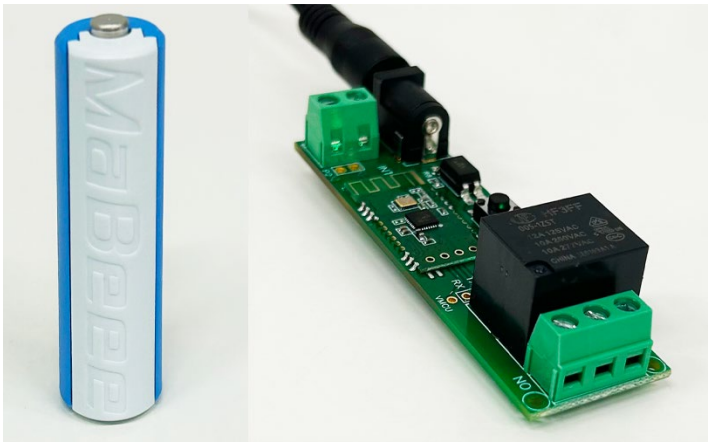
FaceSwitch can integrate with external devices via either Bluetooth-connected switch interfaces (such as relays or MaBeee) or standard iOS/iPadOS apps such as "Home" and "Shortcuts." This enables users to control a variety of devices and applications. Supported connections include:

Bluetooth Relay Modules:

Compatible devices include:

- DSD TECH SH-BT01A Bluetooth Module
- DSD TECH 2-Channel Bluetooth 4.0 BLE Relay Module
- DSD TECH SH-BT04B Bluetooth Module
- TinySine TOSR141 - 4 Channel Bluetooth Relay
- Switch Science ISP1507 Bluetooth Relay Module

(DSD TECH relays are available for purchase in the U.S.)



MaBeee and Bluetooth relay.

Battery-Powered Switch (MaBeee):

- Allows the user to operate battery-powered devices.

iOS/iPadOS "Home" App Integration:

- Enables ON/OFF control of smart home devices that conform to the Matter standard.

iOS/iPadOS "Shortcuts" App Integration:

- Allows users to execute multi-step actions and automations, including operating other applications or devices.

These functions make FaceSwitch versatile, allowing it to be deployed in clinical, home, and educational environments to support a wide range of user needs.

YouTube Video - Operation on MaBeee and Bluetooth relay.
https://www.youtube.com/shorts/b3tTAhLJutY

TECHNICAL ADVANTAGES OF FACESWITCH

FaceSwitch offers several distinct technical benefits compared to conventional switch devices:

No Physical Fitting Required:

Unlike physical switches that require careful placement and attachment, FaceSwitch works without contact and remains functional even if the user's position changes.

No Internet Connection Needed:

The app functions entirely offline, making it suitable for hospitals or care facilities where internet access may be limited or unavailable.

Remote Facial Recognition:

Facial movements can be recognized even when the camera is installed at a distance (up to approximately 15 feet under standard conditions). A high-precision Face ID-compatible camera (currently under development) is expected to offer accurate recognition at distances up to 7 feet.

Seamless Transition from Hospital to Home:

Since FaceSwitch is designed for iOS/iPadOS devices, users can continue using the same device setup after discharge, helping reduce the need for retraining.

High-Accuracy Recognition of Voluntary Movement:

The app's AI can accurately detect intentional facial gestures even in the presence of involuntary movements, providing stable and reliable input.

CASE STUDIES

Case 1: Male with Cerebral Palsy (Functional Implementation)

Patient A, who has cerebral palsy, is bedridden and has limited ability to move—only eye and mouth movements. Involuntary movements interfered with traditional switch use. With FaceSwitch, however, the system can isolate intended gestures like "looking up" or "opening the mouth" from unrelated movement. Patient A now uses FaceSwitch to independently control his television. Future improvements in AI-based learning may further stabilize performance.

Case 2: Male with Progressive Muscular Dystrophy (Calibration Phase)

Patient B uses a nasal ventilator, which originally interfered with face detection. After AI model retraining using image data from ventilated users, FaceSwitch now detects his gestures accurately. While still in testing, this function could soon benefit users with similar needs.

Using Face Switch while wearing a nasal mask.

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Case 3: Female ALS Patient (Advanced Development)

Patient C can only move her eyes very slightly and slowly. Existing eye-tracking systems failed to detect her gaze. FaceSwitch is being enhanced with sensitive motion detection and individualized thresholds to interpret minimal eye movement. Though this function is under development, it shows promise as a final-resort communication tool for advanced ALS patients.

These cases show that:

- FaceSwitch is already feasible and effective for users like Patient A.
- It is nearing readiness for users like B.
- It holds good potential for users like C with profound limitations.

CONCLUSION

FaceSwitch is an innovative communication solution that maximizes residual motor function through AI-based facial recognition. It provides intuitive control for people with severe motor and neurological disabilities and can be deployed in various settings such as hospitals, schools, and homes.

The system enhances quality of life and enables communication even for users who cannot operate traditional switches. Features such as automated logging of gesture frequency and compatibility with respiratory mask users are under development. Future updates will incorporate these enhancements, expanding its use in clinical and research applications.

Importantly, FaceSwitch should be used with caution in contexts involving intellectual disabilities. Misinterpreting involuntary movements as intentional may lead to misleading communication. Particularly for children with limited expressive and receptive abilities, careful observation and support are necessary.

FaceSwitch will continue evolving through interdisciplinary research and user feedback. We plan to present the latest version at the upcoming Closing the Gap Conference, and look forward to advancing inclusive technology for people with the most complex needs. ■