JoyFace - Facial expressions for controlling a wheelchair

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Abstract— Assistive robotics solutions help people regain their mobility and autonomy lost in their daily lives. This work proposes the development of a human-computer interaction based on computer vision called JoyFace. It features a solution for people with motor disabilities such as cerebral palsy, muscular dystrophy, amyotrophic lateral sclerosis, cerebro vascular accident among others. It allows using a front camera already existing in most devices and controlling them through expressions or facial movements. A wheelchair simulation has also been developed and can be tested in real time on this executable paper.

Keywords— Computer Vision, Robotized Wheelchair, Assistive Technology, Human Machine Interface

Resumo— As soluções de robótica assistiva ajudam as pessoas a recuperar sua mobilidade e autonomia perdidas em suas vidas diárias. Este trabalho propõe o desenvolvimento de uma interação homem-computador com base na visão computacional chamada JoyFace. Possui uma solução para pessoas com deficiência motora, como paralisia cerebral, distrofia muscular, esclerose lateral amiotrófica, acidente vascular cerebral, entre outros. Permite usar uma câmera frontal já existente na maioria dos dispositivos e controlá-los através de expressões ou movimentos faciais. A simulação de cadeira de rodas também foi desenvolvida e pode ser testada em tempo real neste papel executável.

Palavras-chave— Visão Computacional, Cadeira de Rodas Robotizada, Tecnologia Assistiva, Interface Humano Computador

1 Introduction

According to (World Health Organization, 2011), more than one billion people in the world suffer from some form of disability, being about 200 million with considerable functional difficulties. In Brazil, over 45 million of the population have some disability, among which 13 million of them suffer from severe motor disabilities (IBGE, 2010).

Recent works bring different solutions for wheelchair alternative controls. (Chauhan et al., 2016) developed a wheelchair controlled by voice commands, however this solution can have the influence of the environment's sounds.(Kim et al., 2013) implemented a control based on commands sent through the tongue. (Rohmer, Pinheiro, Raizer, Olivi and Cardozo, 2015) proposed a control for assistive robotics vehicles using small movements of the face or limbs through Electromyograph (EMG) and signals generated by brain activity Electroencephalograph (EEG).

The JoyFace is a system based on Computer Vision developed to control a wheelchair through facial expressions. The video 1 shows a preview of the system overview, utilizing a simulation. This Human Machine Interface considers the displacement of the user's face relative to a reference region.The face is identified by a regular webcam and verify the face positions. Each position is associated with a movement control of the wheelchair.

In this article, we present a simulation of a Machine Human Interface (HMIs) to control a robotized wheelchair using the head displacement and facial expressions. The early results have to lead us to conclude that the system needs several modifications to be considered as a safe and reliable solution for people paralyzed from down the neck.

2 Methods

In performing this work, was first necessary to define which facial expressions should be used in the proposed human-computer interaction. We analyzed a range of possible facial expressions and observed which are frequently used involuntarily and those that are used voluntarily. This phase is important because it prevents us from adopting an interaction that generates false negatives or false positives throughout its use.From this point will be implemented computer vision techniques through the OpenCV library using a regular webcam.

The displacement of the face was selected to indicate the movement of the wheelchair up, to the right and the left, by offering an intuitive control option for the user. The smile was chosen for the stop function because although it is the facial expression that can be involuntary is simple identification by the system and after a brief period of training the user can offer the commands that want at the right time.

The system consists of a robotized wheelchair simulated in the V-REP software and a Human Machine Interface (HMI) called JoyFace. Figure 1 illustrates the system overview of the real robotized wheelchair. In this Master's thesis (Júnior, 2016) documented its architecture, models, control and applications used in this wheelchair, the author has analyzed many commercial and academic developed wheelchairs and based on his research he proposed an architecture of robotic wheelchair that could be controlled by a wide range of assistive interfaces.

An Arduino Mega 2560 is responsible for connecting some sensors and providing the embedded control to actuate on the independent modules of the rear wheels whereas the front caster wheels can roll freely. This mobile robot has two emergency stop buttons one close to each arm support. One encoder in each motor to measure the wheels' dislocation and a laser range finder to measure distances to obstacles.

A Raspberry Pi Mobel B+ implements the communication between high-level applications and the low-level layer which is responsible for the control and sensing. The software embedded in this intermediate layer is a RESTful application which uses HTTP protocol. In this way, we can use any programming language that can handle HTTP requisitions to communicate with the robotized wheelchair.

In this work, we have the robotic room of the DCA department simulate in the V-REP environment that allows us utilized this robotized wheelchair. The Virtual Robot Experimentation Platform or simply V-REP is a framework of simulator versatile and scalable. Has a remote API interface that allows interacting with an external entity via socket communication. It is composed of remote API server services and remote API clients. The client side can be embedded as a small footprint code (C/C++, Python, Java, Matlab & Urbi) in virtually any hardware including real robots, and allows remote function call, as well as fast data streaming back and forth.

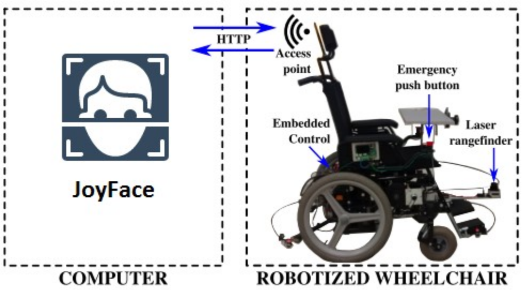

Figure 1 – The system overview

2.1 JoyFace

The JoyFace HMI considers the displacement of the user's face about a reference region. The face is identified by a regular webcam and verify the face positions. Each position is associated with a movement control of the wheelchair.

JoyFace was implemented in Python language and uses face detection based on the Viola-Jones classifiers incorporated into the OpenCV library (Viola and Jones, 2001).These classifiers use Haar Cascade features that are applied to images in real time (Papageorgiou et al., 1998). After detection of the user's face, we observed the last 40 frames. From there the average face position is calculated, and a reference region demarcated. This reference region will remain static when using JoyFace and can be viewed as a white rectangle.

The centroid of the face detection square is calculated in real time and receives a green circle to highlight the displayed image. This way the user can send commands through the displacement of his nose that has the same position of the calculated centroid. Figure 2 shows how JoyFace HMI it works. If the user puts the nose above the reference region, the wheelchair begins to move front, if the nose is positioned to the right or left the wheelchair moves to the corresponding side and the smile interrupts the movement of the wheelchair.

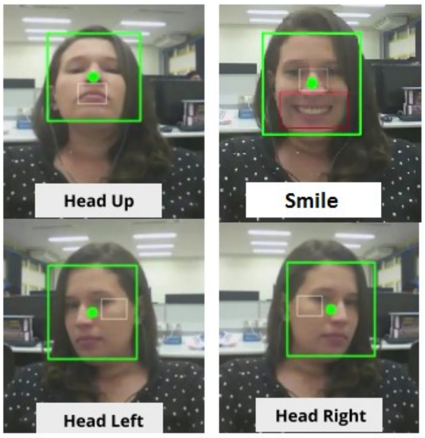

Figure 2: *JoyFace* facial expressions commands used to control the robotized wheelchair.

3 Workflow of the system

We collect the data in real time, utilizing the webcam interface, how can be seen in the Figure 3, the next step it transforms the images in grayscale to improvement the performance. Then we use the OpenCV's classifiers to identify the user's face utilized the green color to demarcated.

The nose point it's calculated during the execution from the centroid of the face. The smile it's classified using the OpenCV's file too, and we utilize to stop the wheelchair. A threshold white reference area it's created to indicate to the user the directions of the wheelchair movements. And finally, the commands can be sent for the V-Rep simulate and control the robotic wheelchair.

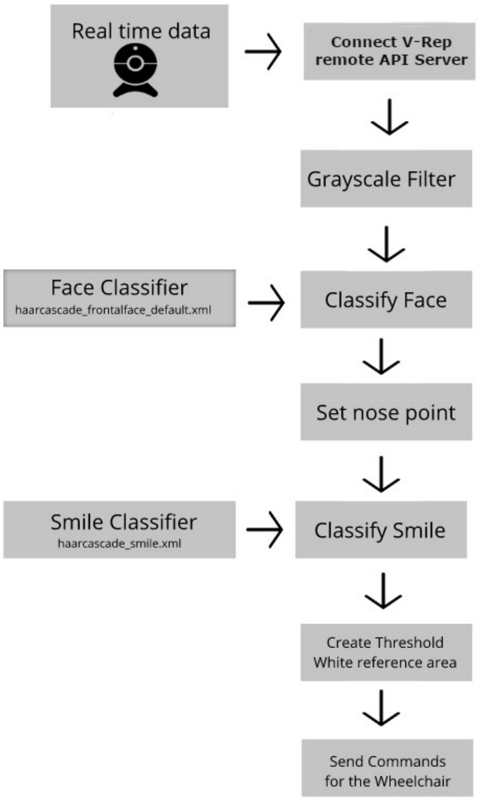

Figure 3 – Workflow of the JoyFace integrated with V-Rep simulate

4 Conclusion

This work proposed a solution that will offer to the person with the motor disability, independence, and autonomy of locomotion, in addition to the control of the environment where it is inserted, thus, improving its quality of life and social inclusion. The results obtained can be replicated through the simulation code available in the annexes of this paper.

Although the results achieved are promising, these upsides rely on the feedback screen with the user's face image captured by the notebook webcam. During the navigation, the operator tends to look at the screen to monitor if he is positioning the face landmark (centroid) out of the reference square and indeed actuating on the wheelchair. The user feels forced to look at the screen during the most of the navigation which is a limitation, as he can not move his head freely without sending undesirable commands to the wheelchair.

As future work, we hope to associate a new facial expression to turn on and off the wheelchair movement system. In this way, the user will have more freedom to do their activities and choose the moment when they want to move the wheelchair.

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