International Journal on Emerging Technologies **11**(2): 541-548(2020)
ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

A Fuzzy Logic based Approach for Replacing Mouse by Facial Expressions for People with Disability in Movement

Pradeep V.[1,3] and Jogesh Motwani[2,3]
[1]Research Scholar, Department of Computer Science and Engineering,
Channabasaveshwara Institute of Technology, Tumkur (Karnataka), India.
[2]Professor, Department of Computer Science and Engineering,
Channabasaveshwara Institute of Technology, Tumkur (Karnataka), India.
[3]Visvesvaraya Technological University, Belagavi (Karnataka), India.

(Corresponding author: Pradeep V.)
(Received 18 December 2019, Revised 12 February 2020, Accepted 15 February 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Many authors had proposed solutions in the past three decades for replacing the mouse for people with disability in the movement who have not yet received a fair chance like others to use the standard input devices of a personal computer. In the camera-based systems, the web camera is used as the mouse that reduces the overhead of using head-mounted devices. Tracking the user's facial expression of different users with different head pose through the camera and converting accurately into the mouse cursor movement and click events are the research challenges and opportunities. The current systems lose the tracked feature during the user's unintentional head movements and they are only comfortable in moving the cursor on a slanting direction. The proposed system applies fuzzy logic in its decision-making to simplify and improve the efficiency of controlling the cursor and its interactions on the Graphical user interfaces to make the people with disability in the movement to use the computer conveniently and easily. The system addresses the problem of feature loss by mapping the mouse cursor movement only with the intentional head movement ignoring the usual head movements. The system also achieves the horizontal and vertical movement of the cursor. The mouse operations are replaced by the head movement and the eyes-blinks captured by the camera. The head movement controls the mouse cursor; left and right eye-blinks replace the actions of the left-click and right-click of the mouse.

Keywords: alternative mouse; assistive technology; camera mouse; gesture recognition; hands-free computing; people with disability.

Abbreviations: GUI, graphical user interface; ROI, Region of Interest; open CV, Open Source Computer Vision Library; CPU, central processing unit; GHz, gigahertz; GB, gigabyte; RAM, random-access memory.

I. INTRODUCTION

About 3 Cr persons are 'disabled' in India as per the Census report 2011. 20% of the disabled persons in India are having a disability in movement, which is about 5.4 million. Persons who are paralysed, not having either both the arms or both the legs and unable to move but crawl are considered as Persons with Disability in movement [1]. People with disability in the movement have not yet received a fair chance like others to incorporate themselves in the world of Information Technology. Their mobility impairment makes them difficult to use the keyboard and mouse, the standard input devices of a personal computer. Many mouse replacement solutions had been proposed in the past three decades. Few solutions rely on special hardware and software designed specifically for people with disability in movement such as Hutchinson *et al*., [2]. Few solutions were developed that can be used only for specific and very limited applications such as Takami *et al*., [3]. Most of the mouse replacement solutions were driven by high-cost hardware system such as Morimoto *et al.,* [4]. Most of the mouse replacement solutions require special hardware that enable the user to operate the computer by usually wearing on and operating through the face or head such as [5-14]. To witness more advancement in the head-mounted technology used for replacing the physical mouse, few solutions have tracked the eye gaze movements to control the mouse cursor on the screen such as [15-19]. To reduce the overhead of using high-cost hardware system and head-mounted devices, few solutions capture user's head motions with web cameras to control the mouse pointer such as [20-44]. Naturally, people look at the object they wish to interact with. Hence few works are done on moving the mouse cursor based on eye movement to make more effective than tracking the head movement and other parts of the head or face such as [45-47, 20-22]. To accurately estimate what a user is focusing on the computer screen, the user's gaze direction should be tracked and not just the eye movements. Eye gaze pointing is a very spontaneous means of pointing and almost no training is required for the user. Few works were focused on tracking eye gazes such as [48-51]. Many systems use speech recognition as a user interface to maintain simplicity for mapping the mouse click events such as [10, 27, 35]. Few camera-based mouse replacement solutions had implemented mouse click events like dragging, left-click, right-click, single click and double click such as [20-22, 25-40, 42, 44, 45, 46, 52, 53, 54]. The survey on mouse replacement solutions for people with disability in movement paves the way for identifying future directions for research and development. Tracking the user's facial expression of different users with different head pose through the camera and converting accurately into the mouse cursor movement and click events is identified as a research challenge and opportunity.

Few limitations on implementing the mouse replacement solutions through web camera have not been addressed. Connor *et al.*, [22], Woramon *et al.*, [31], Sancheti *et al.*, [55] and Nasor *et al.*, [56] have experienced difficulty in using the common GUI interactive features such as scroll bars and menus which require horizontal or vertical movement but the cursor moves slanting. Zhu *et al.*, [29], Vasanthan *et al.*, [39], Magee *et al.*, [48], Sugano *et al.*, [49] and Valenti *et al.*, [51] find difficult to synchronize the rate of the mouse cursor movement with the rate of head movement. The systems designed by Betke *et al.*, [20] and Bourel *et al.*, [57] often lose the facial feature selected to track, when the user moves the head quickly or out of the frame, failing the smooth conversion of the mouse pointer movement.

The Proposed system maps the mouse cursor movement only with the intentional head movement ignoring the usual head movements to address the problem of feature loss. The system also achieves the horizontal and vertical movement of the cursor which is necessary to use the common GUI interactive features such as scroll bars and menus.

II. APPLYING SOFT COMPUTING TECHNIQUES

Tracking the head movement and Eyeblink is an imprecise computational task where soft computing techniques can be applied to exploit the tolerance for imprecision and to make complex decisions and choose the best outcome. Fuzzy logic, Neural network and Genetic algorithm techniques can be used to improve the efficiency of the system.

Head movement and Eyeblink are physiology phenomenon of fuzziness and therefore fuzzy logic can be employed to make computer to determine the distance, direction and rate of head movement; and frequency and interval between the successive eyeblinks.

Neural networks can be used to predict the object to be selected in the screen, while the user is trying to move the cursor, based on the previous learning experience. A neural network has to be trained so that a known set of inputs produces the desired outputs.

Genetic algorithms can be used for feature selection, the process of finding the most relevant inputs for predicting the output (object to be selected in the screen) by identifying and removing unneeded, irrelevant and redundant features that do not contribute or decrease the accuracy of the predicted output [58].

III. METHODOLOGY

The proposed system applies fuzzy logic in its decision-making to simplify and improve the efficiency of controlling the cursor and its interactions on the Graphical user interfaces to make the "mobility-impaired" people those who are prevented from moving the mouse or any pointing device use the computer conveniently and easily.

The mouse operations are replaced by the head movement and the eyes-blinks are captured by the camera. The head movement controls the motion of the cursor, left-eye blink replaces the action of the left-click and right-eye blink replaces the action of the right-click of the mouse.

The initial operation of the proposed system is to capture the head, left eye and right eye of the user. The movement of the head and blinking of left and right eyes are captured with the regular time interval and the respective actions are triggered in the GUI.

To ignore the normal eyeblinks, the right eye should be opened during the left click and left eye should be opened during the right click.

The fuzzy input variations of detection of head movement are constituted by the distance, direction and the rate of head movement whereas eye blink is constituted by blinking period and eye blinking interval. We combine the above-mentioned input variations with fuzzy logic; it will be reflected in the cursor movement and mouse clicks. The appropriate threshold can be set to reject the usual and unexpected head movements and eye blinks.

The components of the proposed fuzzy control system are shown in Fig. 1.

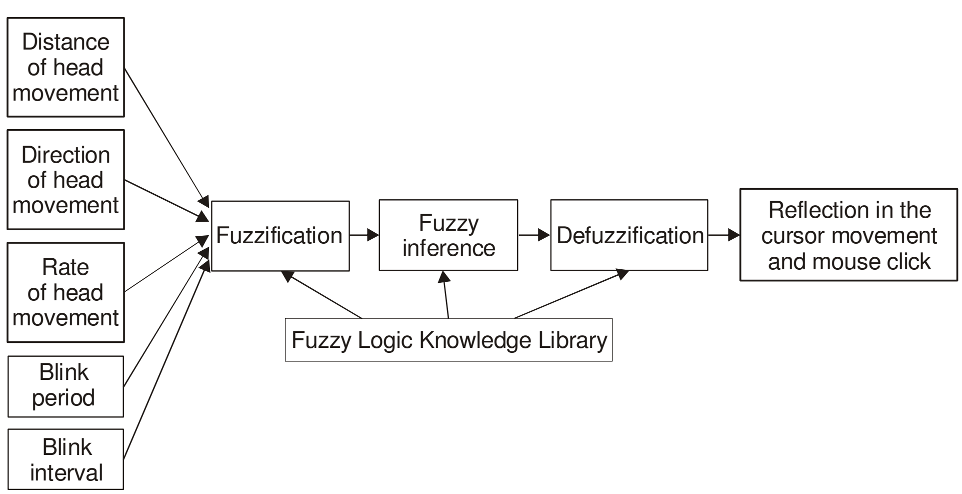

Fig. 1. Components of the fuzzy control system.

A. Inputs to the fuzzy system

The inputs of the fuzzy control system, 'Distance of head movement', 'Direction of head movement' and 'Rate of head movement' are reflected in the movement of the mouse cursor. The other inputs 'blink period' reflects in the single click event and 'blink interval' reflects in the double click event.

Distance of head movement. The Region of Interest (ROI) is the rectangular region of the face captured in the current frame captured by the camera. The top-left corners of the ROIs of the current frame and previous frame are compared to get the distance of head movement. Distance in the horizontal direction is (Face2x-Face1x) and the vertical direction is (Face2y-Face1y), where Face2x and Face2y are the x and y positions of the top-left corners of the Face ROIs in the current frame and Face1x and Face1y are the positions in the previous frame captured by the camera.

Direction of head movement. The direction of head movement is 'north' when the value of (Face2y-Face1y) is negative and 'south' if the value is positive. The direction is 'west' when the value of (Face2x-Face1x) is negative and 'east' if the value is positive. Combination of the both gives the following directions: north-east, north-west, south-east and south-west.

Rate of head movement. The rate of head movement is 'low' when the value of both (Face2x-Face1x) and (Face2y-Face1y) are below the minimum threshold value M_{low}; 'high' when the value of either (Face2x-Face1x) or (Face2y-Face1y) is above the maximum threshold value M_{high}; otherwise, the rate of head movement is 'fair'.

Blink period. Blink period is the number of the consecutive frames where the eye is not detected between the frames where the eye is detected.

Blink interval. Blink interval is the number of the consecutive frames between two blinks (blink periods).

B. Fuzzification and Defuzzification

The fuzzy system uses the following linguistic variables: Direction, Strength, Output, blink_period and blink_interval.

The set of decompositions for these linguistic variables are defined as

Direction = {Null, Positive, Negative}
Strength = {Weak, Moderate, Strong}
Output = {Weak-Positive, Weak-Negative, Moderate-Positive, Moderate-Negative, Strong-Positive, Strong-Negative}
Blink_period = {Usual, Intentional, Surplus}
Blink_interval = {Short, Normal, Long}

Each member of these decompositions are called a linguistic term and can cover a portion of the overall values of the linguistic variables.

The value for the linguistic variable 'Direction' is set based on the values of input 'Distance of head movement' as follows:

If Distance is 0, then: Direction=Null
Else: Direction=Positive|Negative

Further, the relationship between the linguistic variable 'Direction' and the input 'Direction of head movement' is shown in Table 1.

Table 1: The relation between the linguistic variable 'Direction' and the input 'Direction of head movement'.

Direction	x-axis	y-axis
North	Null	Negative
South	Null	Positive
West	Negative	Null
East	Positive	Null
north-east	Positive	Negative
north-west	Negative	Negative
south-east	Positive	Positive
south-west	Negative	Positive

The value for the linguistic variable 'Strength' is set based on the values of input 'Rate of head movement' and the relation is shown in Table 2.

Table 2: The relation between the linguistic variable 'Strength' and the input 'Rate of head movement'.

Rate	x-axis	y-axis
Low	Weak	Weak
Fair	Weak	Moderate
High	Weak	Strong
Fair	Moderate	Weak
Fair	Moderate	Moderate
High	Moderate	Strong
High	Strong	Weak
High	Strong	Moderate
High	Strong	Strong

The value for the linguistic variable Output is set as follows:

```
if(Direction==Positive)
{
    if(Strength==Weak)
        Output=Weak_Positive;
    if(Strength==Moderate)
        Output=Moderate_Positive;
    if(Strength==Strong)
        Output=Strong_Positive;
}
if(Direction==Negative)
{
    if(Strength==Weak)
        Output=Weak_Negative;
    if(Strength==Moderate)
        Output=Moderate_Negative;
    if(Strength==Strong)
        Output=Strong_Negative;
}
```

The defuzzification for the linguistic variable Output is set as follows:

Weak_Positive, Weak_Negative, Strong_Positive, Strong_Negative = 0;

Moderate_Positive, Moderate_Negative(x-axis) = (facex1-facex2)*nx;

Moderate_Positive, Moderate_Negative(y-axis) = (facey1-facey2)*ny;

where nx and ny are the factors set by the user to decide the rate of the cursor movement in the screen concerning the head movement.

The value for the linguistic variable Blink_period is set as follows:

– Usual: between 0 and t1
– Intentional: between t1+1 and t2
– Surplus: above t2

where t1 and t2 are the time duration in terms of the number of frames.
The value for the linguistic variable Blink_interval is set as follows:
– Short: between 0 and T1
– Normal: between T1+1 and T2
– Long: above T2
where T1 and T2 are the time duration in terms of the number of frames.
The 'output' value in the x-axis and y-axis are reflected in the mouse cursor movement in the screen. The single-click is executed if the Blink_period is 'Intentional'. The double click is executed if the following three events occur in sequence: 1. 'Intentional' Blink_period, 2. 'Normal' Blink_interval and 3. 'Intentional' Blink_period.

IV. EXPERIMENT

The system is tested in the laptop computer with the following configuration:
– Intel Pentium CPU B950 2.10 GHz, 2 GB RAM
– Logitech C170 Webcam
– Windows 7 Professional 32-bit Operating System
– 1366 x 768 Screen Resolution with Landscape orientation
– Microsoft Visual C++ 2008 Express Edition
– OpenCV 2.1.0
The pre-trained Haar Cascade classifier algorithms of OpenCV, the most popular library for computer vision, are used for detecting the face and eyes. The Region of Interest, which is a rectangular subset of the image, is acquired using the CvRect structure [59].
The value of the linguistic variable Direction (Null | Positive | Negative) is calculated directly by the results of (Face2x-Face1x) and (Face2y-Face1y).
The value for the linguistic variable Strength (Weak | Moderate | Strong) is calculated based on the rate of the head movement (low | fair | high). The minimum threshold value $M_{low}(x)$ and the maximum threshold value $M_{high}(x)$ in the horizontal direction is set as 6 and 45 by observing the average values of (Face2x-Face1x) by keeping the head stable and moving the head intentionally that is depicted in Fig. 2 and 3. Similarly, the minimum threshold value $M_{low}(y)$ and the maximum threshold value $M_{high}(y)$ in the vertical direction is set as 8 and 35 by observing the average values of (Face2y-Face1y) by keeping the head stable and moving the head intentionally that is depicted in Fig. 4 and 5.

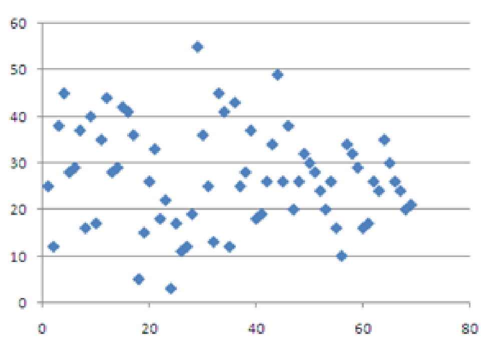

Fig. 2. Graphs for the value (Face2x-Face1x) by keeping the head stable.

M_{low} and M_{high} are the upper limits of the values of the graphs. The x-axes of the graphs denote the frame numbers and the y-axes denote the distance as the number of pixels. The (i,j)th value in the graph gives the information that the distance between the face ROIs of the (j+1)th and jth frames captured by the camera is 'i' pixels.

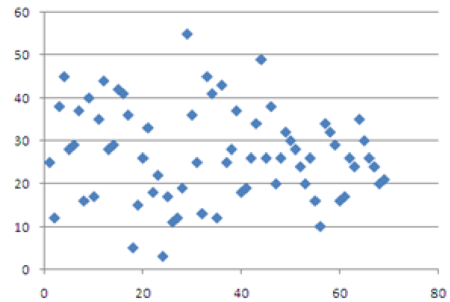

Fig. 3. Graphs for the value (Face2x-Face1x) by moving the head intentionally.

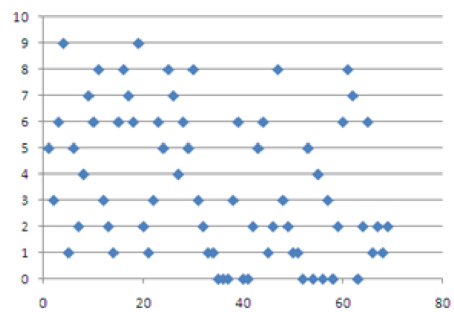

Fig. 4. Graphs for the value (Face2y-Face1y) by keeping the head stable.

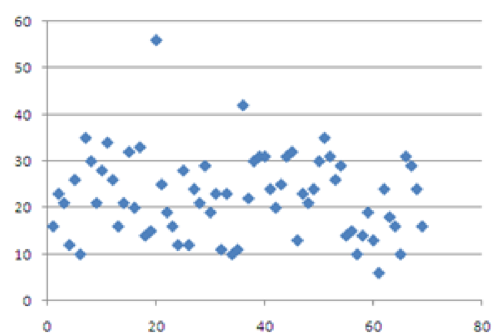

Fig. 5. Graphs for the value (Face2y-Face1y) by moving the head intentionally.

The values of n_x and n_y required for the defuzzification for the linguistic variable Output are decided as 3 and 5 as the rate of the cursor movement on x-axis and y-axis concerning the head movement.
The intentional blink_period is set between 8 and 12 number of frames i.e., the values of t1 and t2 are set as 7 and 12. Hence the usual blink_period is below 8 and the surplus blink_period is above 12 number of frames.
The normal blink_interval is set between 4 and 6 number of frames i.e., the values of T1 and T2 are set as 3 and 6. Hence the short blink_interval is below 4 and the long normal blink_interval is above 6 number of frames.

V. RESULT

The web camera is placed to capture the user's face. To check the accuracy of mouse cursor movement, 10 users were asked to intentionally move the head to move the cursor from the current position to the left-most, right-most, top-most and bottom-most corners of the screen. The same users were also asked to test the left-click and right-click mouse events. Fig. 6 and 7 illustrate the user's interaction with the computer where the head and eyes are tracked. Table 3 shows the accuracy of the mouse cursor on horizontal and vertical movement as an average of 89.25% which is necessary to use the common GUI interactive features such as scroll bars and menus pertaining to the existing systems which are only comfortable in moving the cursor on a slanting direction [22, 31, 55, 56]. Table 4 shows the accuracy of the mouse click event as an average of 87.5%.

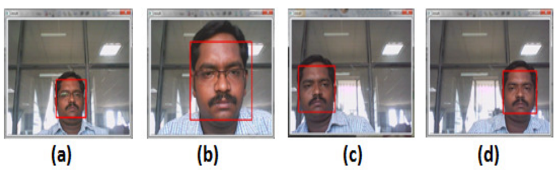

Fig. 6. Moving the cursor (a) down (b) up (c) left and (d) right.

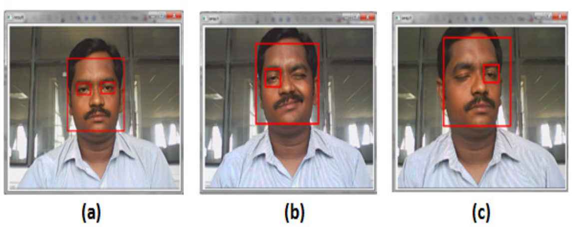

Fig. 4. Mouse click events (a) none (b) left-click and (c) right-click.

Table 3: Accuracy of mouse cursor movement while moving the corners of the screen.

Users	left-most		right-most		top-most		bottom-most	
	Attempts	Achieved	Attempts	Achieved	Attempts	Achieved	Attempts	Achieved
1	10	9	10	10	10	7	10	9
2	10	8	10	9	10	8	10	8
3	10	10	10	8	10	7	10	10
4	10	9	10	10	10	8	10	9
5	10	10	10	10	10	10	10	7
6	10	7	10	8	10	8	10	9
7	10	10	10	10	10	9	10	10
8	10	10	10	9	10	10	10	8
9	10	8	10	10	10	8	10	8
10	10	10	10	9	10	10	10	9
Average: 89.25%								

Table 4: Accuracy of mouse click events.

Users	Left-click		Right-click	
	Attempts	Achieved	Attempts	Achieved
1	10	8	10	8
2	10	8	10	9
3	10	9	10	10
4	10	7	10	8
5	10	10	10	9
6	10	8	10	10
7	10	9	10	7
8	10	10	10	9
9	10	9	10	9
10	10	9	10	9
Average: 87.5%				

As the proposed system maps the mouse cursor movement only with the intentional head movement by ignoring the usual head movements, the problem of feature loss are set right pertaining to the loss of the tracked feature reported by the existing systems during the user's unintentional head movements [20, 57].

VI. CONCLUSION

This paper is focused on providing the advantage of mouse GUI operations available to the people with disability in movement. To reduce the overhead of using high-cost hardware system and head-mounted devices, web camera-based solution is endorsed. To increase in the efficiency of controlling the mouse, the system has applied fuzzy logic in its decision-making to determine the distance, direction and rate of head movement as the head movement is the physiology phenomenon of fuzziness. The appropriate thresholds were set to reject the usual and unexpected head movements. The horizontal and vertical movements of the mouse cursor are achieved which is necessary to use the common GUI interactive features.

VII. FUTURE SCOPE

The system can be improved in many ways including the following:

– Tracking a user's gaze direction accurately
– Recognizing the approximate single-eye wink of different users with different head poses
– Using more efficient fuzzy control functions to improve the efficiency
– Neural network techniques for necessary decision-making and predictions
– Genetic algorithms can be used for feature selection, the process of finding the most relevant inputs for predicting the output.

Conflict of Interest. The authors confirm that there is no conflict of interest in publishing this paper.

REFERENCES

[1]. Social Statistics Division, Ministry of Statistics and Programme Implementation, Government of India, New Delhi, (2017). Disabled Persons in India, A statistical profile 2016. Retrieved from http://www.mospi.gov.in.

[2]. Hutchinson, T. E., White, K. P., Martin, W. N., Reichert, K. C. & Frey, L. A. (1989). Human–computer interaction using eye-gaze input. *IEEE Transactions on Systems, Man, and Cybernetics, 19*(6), 1527-1534.
[3]. Takami, O., Morimoto, K., Ochiai, T., & Ishimatsu, T. (1995). Computer interface to use head and eyeball movement for handicapped people. *Proceedings of IEEE International Conference on Systems, Man and Cybernetics, Intelligent Systems for the 21st Century*, Vancouver, BC, Canada, *2*, 1119-1123.
[4]. Morimoto, C. H., Koons, D., Amit, A., & Flickner M. (1999). Keeping an Eye for HCI. *Proceedings of* XII *Brazilian Symposium on Computer Graphics and Image Processing,* Campinas, Brazil, 171-176.
[5]. Gips, J. (1993). Direct control of the computer through electrodes placed around the eyes. *Human-Computer Interaction: Applications and Case Studies*.
[6]. LaCourse, J. R., & Hludik, F. C. (1990). An eye movement communication-control system for the disabled. *IEEE Transactions on Biomedical Engineering,* 37, 1215-1220.
[7]. Kim, S., Park, M., Anumas, S., & Yoo, J. (2010). Head mouse system based on gyro- and opto-sensors. *Proceedings of 3rd International Conference on Biomedical Engineering and Informatics,* Yantai, China, 1503-1506.
[8]. Takahashi, J., Suezawa, S., Hasegawa, Y. & Sankai, Y. (2011). Tongue Motion-based Operation of Support System for Paralyzed Patients. *Proceedings of IEEE International Conference on Rehabilitation Robotics*, Zurich, Switzerland, 1-6.
[9]. Kuzume, K. (2012). Evaluation of tooth-touch sound and expiration based mouse device for disabled persons. *Proceedings of IEEE International Conference on Pervasive Computing and Communications Workshops*, Lugano, Switzerland, 387-390.
[10]. Honye, S., & Thinyane, H. (2012). WiiMS: Simulating mouse and keyboard for motor-impaired users. *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference,* Pretoria, South Africa, 188-195.
[11]. Chen, Y. L., Tang, F. T., Chang, W. H., Wong, M. K., Shih, Y. Y., & Kuo T. S. (1999). The new design of an infrared-controlled human-computer interface for the disabled. *IEEE Transactions on Rehabilitation Engineering*, *7*(4), 474-481.
[12]. Evans, D. G., Drew, R., & Blenkhorn, P. (2000). Controlling mouse pointer position using an infrared head-operated joystick. *IEEE Transactions on Rehabilitation Engineering*, *8*(1), 107-117.
[13]. Barreto, A. B., Scargle, S. D., & Adjouadi, M. (2000). A practical EMG-based human-computer interface for users with motor disabilities. *Journal of Rehabilitation Research and Development*, *37*(1), 53-64.
[14]. Takami, O., Irie, N., Kang, C., Ishimatsu, T., & Ochiai, T. (1996). Computer interface to use head movement for handicapped people. *Proceedings of Digital Processing Applications (TENCON '96)*, Perth, WA, Australia, *1*, 468-472.
[15]. Chin, C. A., & Barreto, A. (2006). Enhanced Hybrid Electromyogram/Eye Gaze Tracking Cursor Control System for Hands-Free Computer Interaction. *Proceedings of International Conference of the IEEE Engineering in Medicine and Biology Society,* New York, 2296-2299.
[16]. Lyons, E. C., Barreto, A. B., & Adjouadi, M. (2001). Development of a hybrid hands-off human computer interface based on electromyogram signals and eye-gaze tracking. *Conference Proceedings of the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Istanbul, Turkey, *2*, 1423-1426.
[17]. Kocejko, T., Bujnowski, A., & Wtorek, J. (2009). Eye-Mouse for Disabled. *In: Hippe Z.S., Kulikowski J.L. (eds) Human-Computer Systems Interaction. Advances in Intelligent and Soft Computing*, Springer, Berlin, Heidelberg, 60, 109-122.
[18]. Arai, K., & Mardiyanto, R. (2011). Eye based HCI with moving keyboard for reducing fatigue effects. *Proceedings of Eighth International Conference on Information Technology: New Generations*, Las Vegas, NV, USA, 417–422.
[19]. Lupu, R. G., Bozomitu, R. G., Păsărică, A., & Rotariu, C. (2017). Eye Tracking User Interface for Internet Access Used in Assistive Technology. *Proceedings of E-Health and Bioengineering Conference (EHB)*, Sinaia, Romania, 659-662.
[20]. Betke, M., Gips, J., & Fleming, P. (2002). The Camera Mouse: visual tracking of body features to provide computer access for people with severe disabilities. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 10*(1), 1-10.
[21]. Akram, W., Tiberii, L., & Betke, M. (2007). A Customizable Camera-Based Human Computer Interaction System Allowing People with Disabilities Autonomous Hands-Free Navigation of Multiple Computing Tasks. *In: Stephanidis C., Pieper M. (eds) Universal Access in Ambient Intelligence Environments. Lecture Notes in Computer Science,* Springer, Berlin, Heidelberg, 28-42.
[22]. Connor, C., Yu, E., Magee, J., Cansizoglu, E., Epstein, S., & Betke M. (2009). Movement and Recovery Analysis of a Mouse-Replacement Interface for Users with Severe Disabilities. *In: Stephanidis C. (eds) Universal Access in Human-Computer Interaction. Intelligent and Ubiquitous Interaction Environments. UAHCI 2009. Lecture Notes in Computer Science*, Springer, Berlin, Heidelberg, 493-502.
[23]. Epstein, S., Missimer, E., & Betke, M. (2014). Using kernels for a video-based mouse-replacement interface, *Personal and Ubiquitous Computing, 18*(1), 47-60.
[24]. Magee, J. J., Epstein, S., Missimer, E. S., Kwan, C., & Betke, M. (2011, July). Adaptive mouse-replacement interface control functions for users with disabilities. In *International Conference on Universal Access in Human-Computer Interaction* (pp. 332-341). Springer, Berlin, Heidelberg.
[25]. Palleja, T., Rubion, E., Teixido, M., Tresanchez, M., Viso, A.F.D., Rebate, C. and Palacin, J., (2008). Simple and Robust Implementation of a Relative Virtual Mouse Controlled by Head Movements. *Proceedings of Conference on Human System Interactions*, Krakow, Poland, 221-224.
[26]. Kim, H., & Ryu, D. (2006). Computer control by tracking head movements for the disabled. *Proceedings of International conference on computers helping people with special needs,* Linz, Austria, 709-715.

[27]. Loewenich, F., & Maire, F. D. (2007). Hands-free mouse-pointer manipulation using motion-tracking and speech recognition, *Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining User Interfaces*, Adelaide, Australia, 295-302.
[28]. Nabati, M., & Behrad, A. (2015). 3D Head pose estimation and camera mouse implementation using a monocular video camera. *Signal, Image and Video Processing*, *9*(1), 39-44.
[29]. Zhu, H., & Lei, Q. (2008). Vision-Based Interface: Using Face and Eye Blinking Tracking with Camera. *Proceedings of 2nd International Symposium on Intelligent Information Technology Application*, Shanghai, China, 306-310.
[30]. Kumar, S., Rai, A., Agarwal, A., & Bachani, N. (2010). Vision based human interaction system for disabled. *Proceedings of 2nd IEEE International Conference on Image Processing Theory, Tools and Applications*, Paris, France, 441-446.
[31]. Woramon C., Kanhaun, S., Khawkam, K., & Wongsawang, D. (2016). Face and Eyes mouse for ALS Patients. *Proceedings of Fifth ICT International Student Project Conference*, Nakhon Pathom, Thailand, 77-80.
[32]. Yee, C. M., Varona, J., Ribot, T., & Perales, F. J. (2006). Non-verbal communication by means of head tracking. *Proceedings of Ibero-American Symposium on Computer Graphics*, Santiago de Compostela, Spain, DBLP, Germany, 72-75.
[33]. Tu, J., Tao, H., & Huang, T. (2007). Face as Mouse Through Visual Face Tracking. *Computer Vision and Image Understanding*, *108* (1–2), 35-40.
[34]. Varona, J., Yee, C. M., & Perales, F. J. (2008). Hands-free vision-based interface for computer accessibility. *Journal of Network and Computer Applications*, *31*(4), 357-374.
[35]. Chathuranga, S. K., Samarawickrama, K. C., Chandima, H. M. L., Chathuranga, K. G. T. D., & Abeykoon, A. M. H. S. (2010). Hands free interface for Human Computer Interaction. *Proceedings of Fifth International Conference on Information and Automation for Sustainability,* Colombo, Sri Lanka, 359-364.
[36]. Bian, J. P., Hou, J., Chau, L. P., & Thalmann, N. M. (2016). Facial position and expression-based human-computer interface for persons with tetraplegia. *IEEE Journal of Biomedical and Health Informatics*, *20*(3), 915-924.
[37]. Gorodnichy, D. O., & Roth, G. (2004). Nouse 'use your nose as a mouse' perceptual vision technology for hands-free games and interfaces. *Image and Vision Computing*, *22*(12), 931-942.
[38]. Mohamed, A. W., & Koggalage, R. (2007). Control of mouse movements using human facial expressions, *Proceedings of Third International Conference on Information and Automation for Sustainability*, Melbourne, VIC, Australia, 13-18.
[39]. Vasanthan, M., Murugappan, M., Nagarajan, R., Ilias, B., & Letchumikanth, J. (2012). Facial expression based computer cursor control system for assisting physically disabled person. *Proceedings of International Conference on Communication, Networks and Satellite*, Bali, Indonesia, 172-176.
[40]. Kraichan, C., & Pumrin, S. (2014). Face and Eye Tracking for Controlling Computer Functions, *Proceedings of 11th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*, Nakhon Ratchasima, Thailand, 1-6.
[41]. Gyawal, P., Alsadoon, A., Prasad, P.W. C., Hoe, L. S., & Elchouemi, A. (2016). A novel robust camera mouse for disabled people. *Proceedings of 7th International Conference on Information and Communication Systems*, Irbid, Jordan, 217-220.
[42]. Parmar, K., Mehta, B., & Sawant, R. (2012). Facial-feature based Human-Computer Interface for disabled people. *Proceedings of International Conference on Communication, Information & Computing Technology*, Mumbai, India, 1-5.
[43]. Morris, T., & Chauhan, V. (2006). Facial feature tracking for cursor control. *Journal of Network and Computer Applications*, *29*(1), 62-80.
[44]. Eric, M., & Betke, M. (2010). Blink and wink detection for mouse pointer control. *Proceedings of the 3rd International Conference on Pervasive Technologies Related to Assistive Environments*, Samos, Greece, ACM, New York.
[45]. Shin, Y., & Kim, E. Y. (2006, December). Welfare interface using multiple facial features tracking. In *Australasian Joint Conference on Artificial Intelligence* (pp. 453-462). Springer, Berlin, Heidelberg.
[46]. Fathi, A., & Mohammadi, F. A. (2015). Camera-based eye blinks pattern detection for intelligent mouse. *Signal, Image and Video Processing, 9*(8), 1907–1916.
[47]. Kim E. Y., & Kang S. K. (2006). Eye Tracking Using Neural Network and Mean-Shift. *In: Gavrilova M. et al. (eds) Computational Science and Its Applications - ICCSA 2006. ICCSA 2006. Lecture Notes in Computer Science,* Springer, Berlin, Heidelberg, 453–462.
[48]. Magee, J. J., Scott, M. R., Waber, B. N., & Betke, M. (2004). EyeKeys: A Real-time Vision Interface Based on Gaze Detection from a Low-grade Video Camera. *Proceedings of Conference on Computer Vision and Pattern Recognition Workshop*, Washington, DC, USA, 27, 159.
[49]. Sugano, Y., Matsushita, Y., Sato, Y., & Koike, H. (2015). Appearance-based gaze estimation with online calibration from mouse operations. *IEEE Transactions on Human-Machine Systems, 45*(6), 750-760.
[50]. Sambrekar, U., & Ramdasi, D. (2015). Estimation of Gaze for Human Computer Interaction. *Proceedings of International Conference on Industrial Instrumentation and Control*, Pune, India, 1236-1239.
[51]. Valenti, R., Lablack, A., Sebe, N., Djeraba, C., & Gevers, T. (2010). Visual gaze estimation by joint head and eye information. *Proceedings of 20th International Conference on Pattern Recognition,* Istanbul, Turkey, 3870-3873.
[52]. Hegde, V. N., Ullagaddimath, R. S., & Kumuda, S. (2016). Low cost eye based human computer interface system (Eye controlled mouse). *Proceedings of IEEE Annual India Conference (INDICON)*, Bangalore, India, 1-6.
[53]. Chau, M., & Betke, M. (2005). Real time eye tracking and blink detection using USB camera. *Boston University Computer Science Technical Report*, No. 2005-12, 1-10.
[54]. Arai, K., & Mardiyanto, R. (2010). Camera as Mouse and Keyboard for Handicap Person with Troubleshooting Ability, Recovery, and Complete Mouse

Events. *International Journal of Human-Computer Interaction*, *1*(3), 46-56.
[55]. Sancheti K., Suhaas A., & Suresh P. (2018). Hands-free Cursor Control using Intuitive Head Movements and Cheek Muscle Twitches, *TENCON 2018 - 2018 IEEE Region 10 Conference*, Jeju, Korea (South), 0356-0361.
[56]. Nasor M., Rahman K. K. M., Zubair M. M., Ansari H., & Mohamed F. (2018). Eye-controlled mouse cursor for physically disabled individual. *2018 Advances in Science and Engineering Technology International Conferences (ASET)*, 232–241.
[57]. Bourel F., Chibelushi C. C., & Lowe, A. A. (2000). Robust facial feature tracking. *Proceedings of the British machine vision conference (BMVC)*, *1*, 232–241.
[58]. Wikipedia contributors. (2019). Soft computing. *In Wikipedia, The Free Encyclopedia.* Retrieved 14:21, May 3, 2019, from https://en.wikipedia.org/w/index.php? title=Soft_computing&oldid=895153722.
[59]. “Cascade Classifier”, Open CV, (2019) Retrieved from “docs.opencv.org/master/db/d28/tutorial_cascade_classifier.html, Accessed and Generated on Oct 3, 2019.

How to cite this article: Pradeep, V. and Motwani, J. (2020). A Fuzzy Logic based Approach for Replacing Mouse by Facial Expressions for People with Disability in Movement. *International Journal on Emerging Technologies*, *11*(2): 541–548.