Eyelid Gestures for People with Motor Impairments.

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What the paper is about ?

- According to Census 2011, there are 26.8 million people with disabilities in India, making up 2.21 percent of the total population.
- Some of the disabilities (like motor neuron disease) causes even affect in speech.
- Difficulty in communication, and controlling day to day systems.

Problem :
How can we improve human-human and human-computer interaction for people with motor impairments ?

Image Courtesy: Photo by Roman Egorov on Dreamstime

What the paper is about ?

- Existing Technologies and ideas :
  - *Eye-trackers - (motion of the eyes)*
  - *Brain-computer interfaces*
  - *Mechanical devices (e.g., joysticks, trackballs)*
  - *heavy, intrusive, expensive, limited in functions supported (e.g., text entry).*

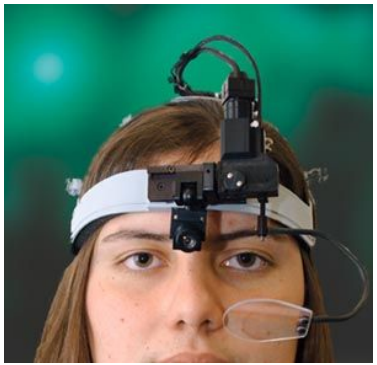
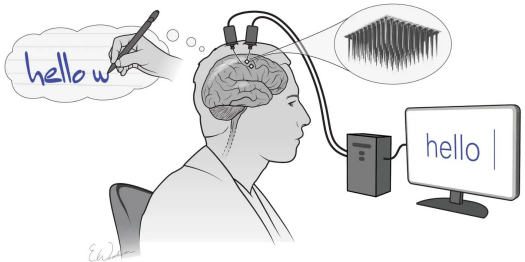


Image courtesy : en.wikipedia.org/wiki/Eye_tracking

- *Can we use something as simple and cheap as a smartphone cameras for making improvements in interaction ?*



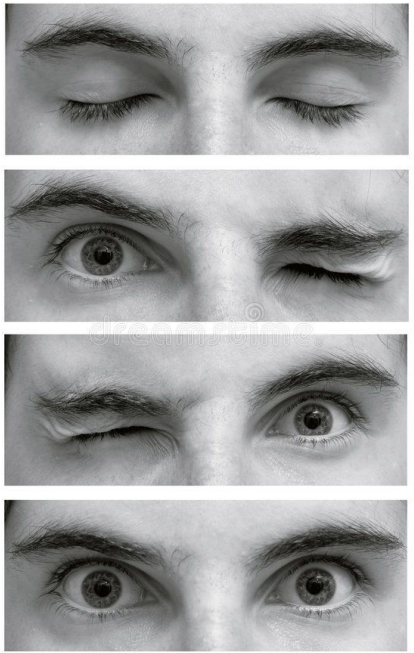
https://www.the-scientist.com/news-opinion/brain-computer-interface-user-types-90-characters-per-minute-with-mind-68762

What the paper is about ?

- It turns out we can use our eyelids to make a series of gestures, much *more than just a wink* !

- Earlier - only eyeball movements and blinks.

The paper discusses what gestures we can do with just a pair of eyelids, algorithm to detect these gestures, and how algorithm performs in real scenario.



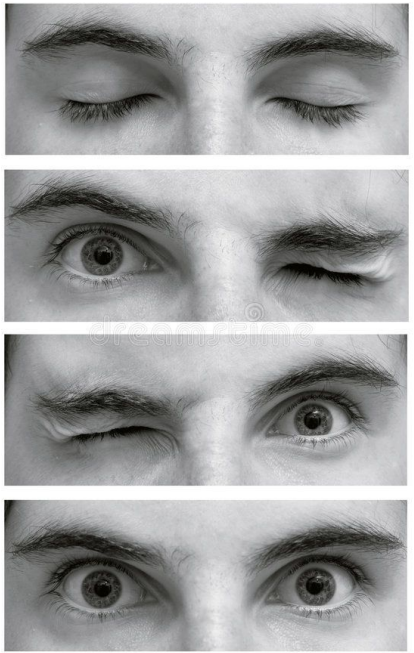
- Photo by Tihis on dreamstime

Eyelid Gesture Design

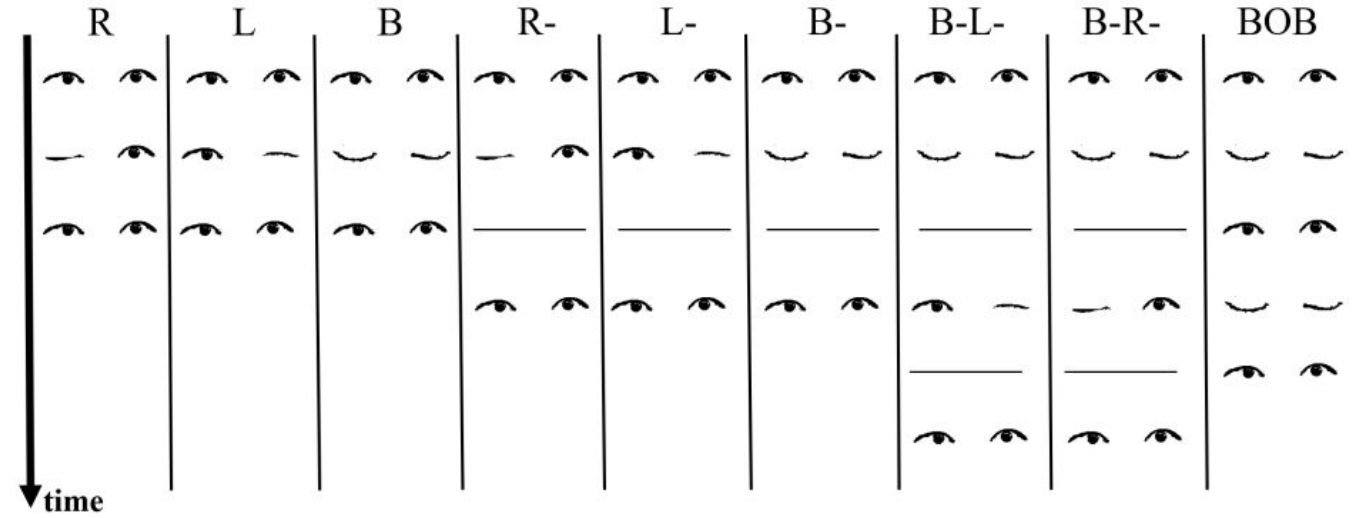
- Four Eyelid states :
  - both eyelids open
  - both eyelids close
  - only the right eyelid close
  - only the left eyelid close.

- Duration of an eyelid state :
  Short and long - both states may be adjusted according to user

- Gesture delimiter : ‘both eyelids open’
  to label the start and end of an eyelid gesture.
  Analogy : Like a full stop at the end of an English Sentence.



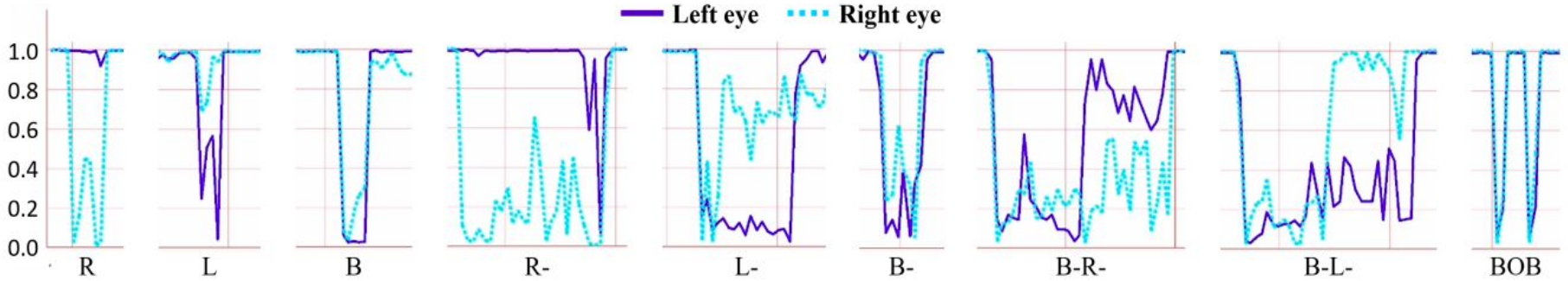
Eyelid Gesture Design



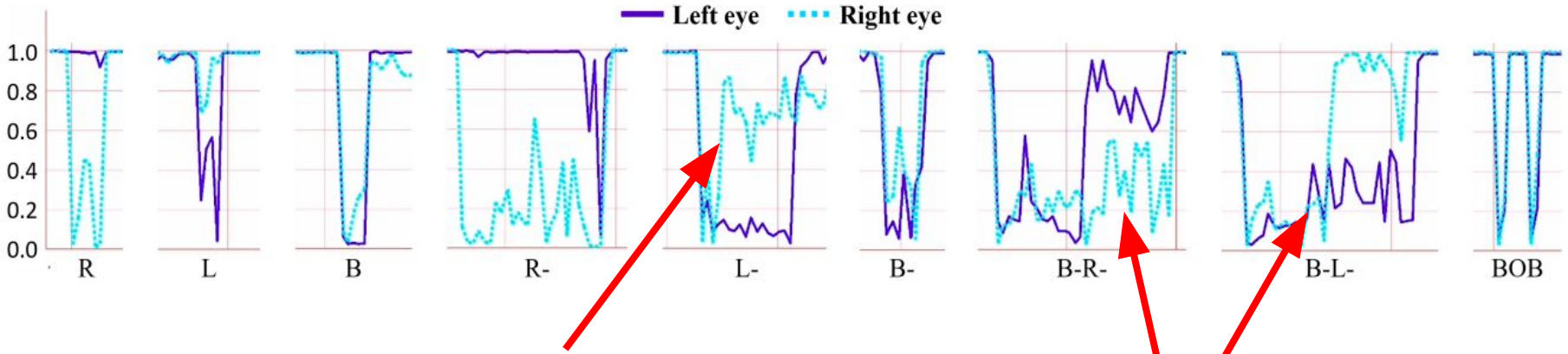
These are the nine eyelid gestures that the algorithm detects. Here B denotes both eyelids closed, O means both eyelids open and R, L denotes left and right eyelid closed respectively. Addition of '-' denotes long duration else it is short duration.

But how do we recognize an eye gesture ?

- Images are collected from the front camera of a smartphone which are then used to generate a stream of probability pairs of each eye being open (P_L, P_R) with time using Google Mobile Vision API.



But how do we recognize an eye gesture ?

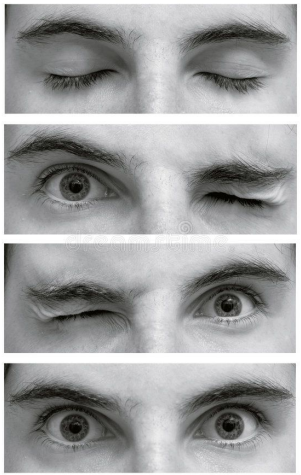


- Noise in the generated stream of probabilities, especially when one eye is open and other eye is closed.
- When one eye is closed, the probability of other eye being open also drops.

But how do we recognize an eye gesture ?

Right Left

Time

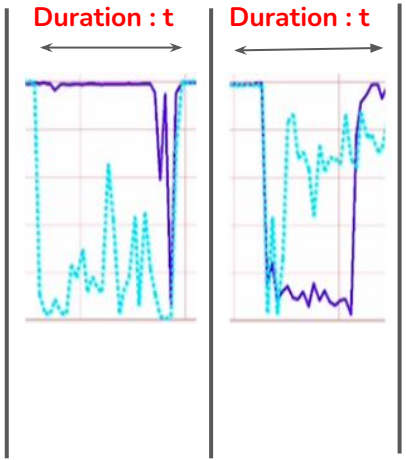


(P_L, P_R) are generated with time continuously.

Time series probabilities generation for eye states

According to Threshold

Duration : t Duration : t



Segmentation

Division based on threshold of "Both Open Eye"

We use an SVM classifier to classify input pair of (P_L, P_R) into "Both Open" or "Any close"

Long Duration → Resampling into 100 samples of (P_L, P_R) pairs.

Short Duration → Resampling into 50 samples of (P_L, P_R) pairs.

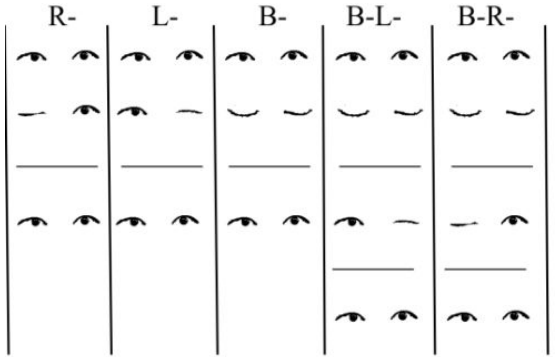
Division of a gesture into Long duration vs Short Duration

Using an SVM classifier.

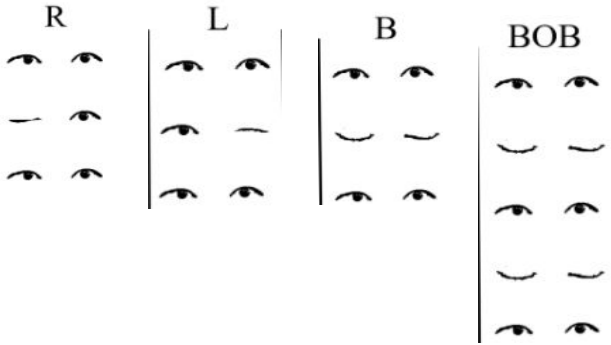
Resampling

But how do we recognize an eye gesture ?

Long Duration Resampled Data (P_L, P_R)



Short Duration Resampled Data (P_L, P_R)



Resampled Data

- Both Long Duration and Short Duration Gestures are classified using different SVM Classifiers.
- SVM - Support Vector Machine algorithm is a popular supervised machine learning classification algorithm.

How do we test our algorithm ?

- The participants sat on a wheelchair and smartphone is placed in front of them.
- Training data is collected for each of the four eyelid states and nine eyelid gestures
- They had to perform the eyelid gesture shown on screen.
- The app showed each eyelid gesture ten times randomly.
- This is then used to train and test the model. Some variation is added in the training and testing data by changing rooms, position of participant etc.
- Participants include 12 healthy individuals and 4 with severe motor impairments.

Results for healthy individuals

User-dependent eyelid gesture evaluation:

- Five samples were used to train and rest 5 were used to test the classifier.
- The overall accuracy is 0.76 (SD = .19)

	R	L	B	R-	L-	B-	B-R-	B-L-	BOB
R	47	0	7	8	0	0	0	1	6
L	4	56	7	1	5	2	2	0	8
B	0	0	46	0	0	0	0	0	0
R-	3	0	0	44	0	5	3	1	2
L-	0	0	0	0	46	4	1	7	0
B-	0	0	0	0	1	45	4	2	0
B-R-	0	0	0	6	0	1	47	1	1
B-L-	0	0	0	1	6	2	1	47	0
BOB	0	1	0	0	0	0	0	0	34
N/A	6	3	0	0	2	1	2	1	9

Confusion Matrix

User-independent eyelid gesture evaluation:

- The data of one user is used for testing and rest participants' data for training.
- The overall accuracy is 0.68 (SD = .17)

	R	L	B	R-	L-	B-	B-R-	B-L-	BOB
R	47	2	7	15	0	3	3	1	7
L	2	53	6	3	13	2	0	0	10
B	0	0	45	0	0	0	0	0	0
R-	3	0	1	36	0	9	4	1	1
L-	0	1	0	0	42	4	0	6	0
B-	0	0	1	4	0	34	10	1	0
B-R-	0	0	0	0	0	2	38	1	0
B-L-	0	0	0	0	3	0	1	46	0
BOB	0	0	0	0	0	0	0	0	28
N/A	8	4	0	2	2	6	4	4	14

Confusion Matrix

Results for people with motor impairments

User-dependent eyelid gesture evaluation:

- Five samples were used to train and rest 5 were used to test the classifier.
- The overall accuracy is 0.76 (SD = .15)

	R	L	B	R-	L-	B-	B-R-	B-L-	BOB
R	15	1	0	2	0	1	0	0	4
L	0	16	0	1	1	0	0	0	0
B	0	0	19	0	0	0	0	0	0
R-	0	0	0	12	0	0	0	0	0
L-	0	0	0	0	17	0	0	2	0
B-	0	0	0	1	1	19	0	4	0
B-R-	1	0	0	2	0	0	20	2	0
B-L-	0	0	0	0	1	0	0	11	0
BOB	0	0	1	0	0	0	0	0	7
N/A	4	3	0	2	0	0	0	1	9

Confusion Matrix

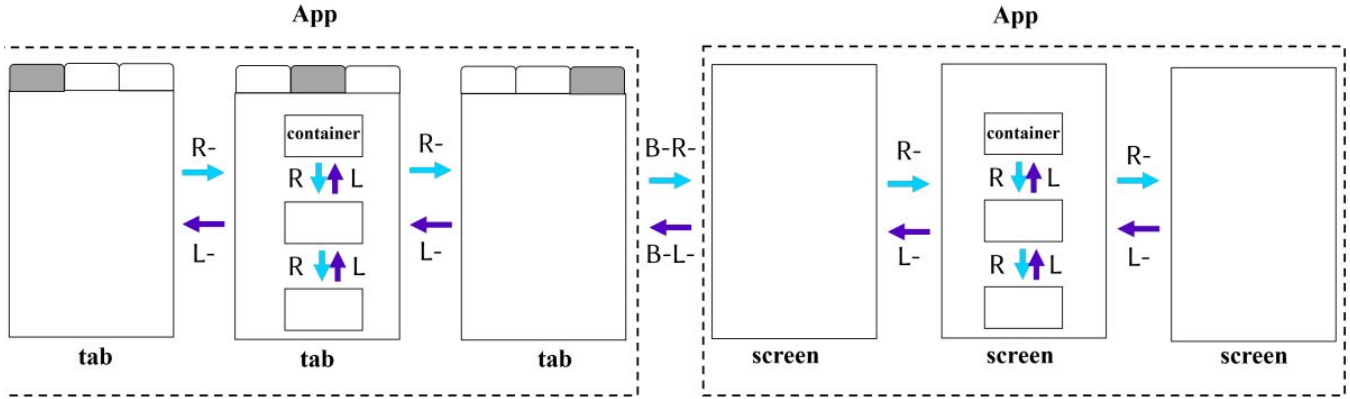
User-independent eyelid gesture evaluation:

- The data of one user is used for testing and rest participants' data for training.
- The overall accuracy is 0.69 (SD = .20)

	R	L	B	R-	L-	B-	B-R-	B-L-	BOB
R	10	0	0	3	0	1	0	0	1
L	2	15	0	2	3	0	0	0	0
B	0	0	17	0	0	0	0	0	0
R-	0	0	0	11	1	0	0	0	0
L-	0	2	0	0	13	0	0	1	0
B-	3	0	2	1	1	19	2	6	1
B-R-	2	0	0	2	0	0	18	0	0
B-L-	0	2	0	0	1	0	0	11	0
BOB	0	0	1	0	0	0	0	1	11
N/A	3	1	0	1	1	0	0	1	7

Confusion Matrix

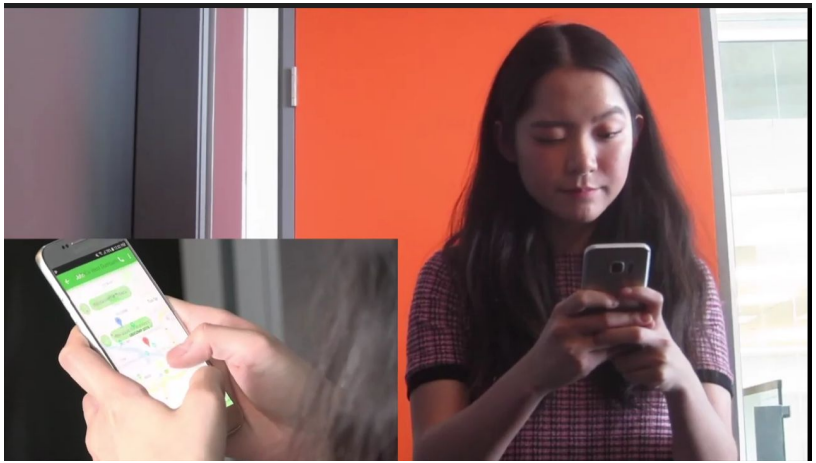
Interacting with smartphone using eyelid gestures



- App navigation happens at three levels: between apps, between tabs/screens in an app, and between containers in a tab/screen of an app.
- Less used commands like switching apps were assigned complex eyelid gestures (B-R-, B-L-).
- In addition to navigation, BOB is used for selecting an item.

Interacting with smartphone using eyelid gestures

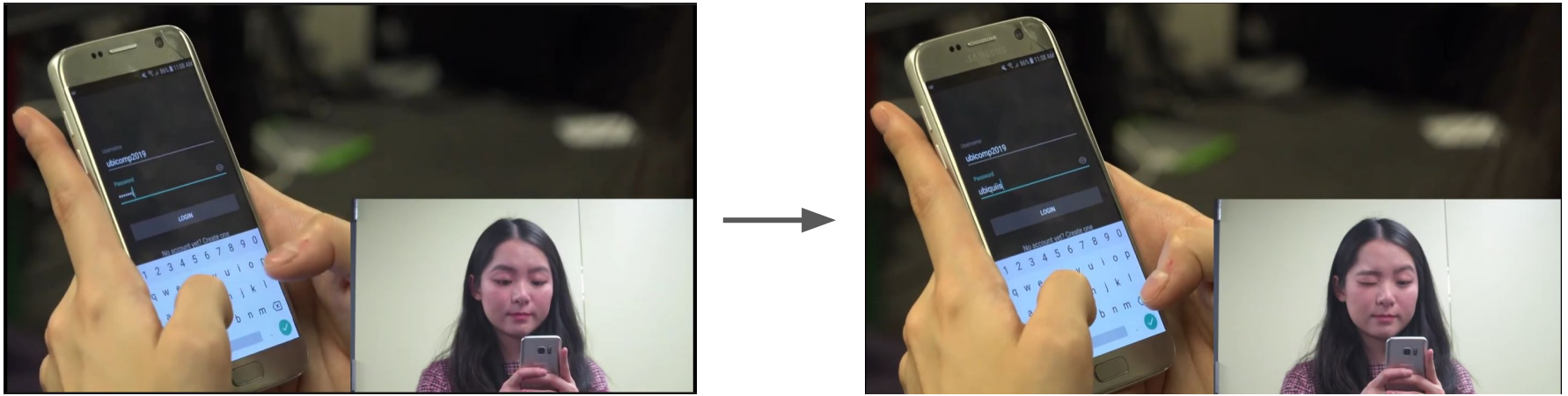
Navigating through apps



Multitasking

Source:
https://www.youtube.com/watch?v=GgpW4tmvdM0

Interacting with smartphone using eyelid gestures



Mode switching with eyelid gestures
(Example - Password can be viewed by right blink)

Source:
https://www.youtube.com/watch?v=GgpW4tmvdM0

Future Work

- **Eyelid states:** Half-closed eyelids could also be included in design space which would result in more eyelid gestures.
- **Duration of eyelid states:** Other levels of duration that users could reasonably distinguish to uncover more eyelid gestures might be added.
- **User-defined eyelid gesture design:** The eyelid gestures could be modified as per user's need.
- **Electronic devices:** This could be further used to control other devices like TVs, ACs and tablets.

Conclusion

- We were able to improve human-computer interaction for both able-bodies and physically challenged people, with a not bulky or expensive instrument.
- We used just a camera and designed some algorithms to solve a real world problem.

- Source : Jay_smith on dreamstime

Thank You

Q/A