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Optimizing a Pilot's Situational Awareness during Landing: a Product Design

Ganesh Sadashiv[1]
Department of Architecture and Design
PES University Bangalore
Bangalore, India

Shruthi Venkat[2]
Department of Architecture and Design
PES University Bangalore
Bangalore, India

Aabharan Hemanth[3]
Department of Architecture and Design
PES University Bangalore
Bangalore, India

***Abstract:** The majority of landings are done manually, with pilot error to blame for most accidents. Pilots utilize the auto landing system only if adverse weather conditions prevail. According to data collated from the worldwide commercial jet fleet (2005 - 2015), about forty-nine percent of fatal accidents take place during final approach and landing. The massive overload of visual and auditory stimuli during a manual landing makes it difficult to compute information fast enough.*

The research in progress focuses on re-distributing the influx of stimuli to the pilot, increasing situational awareness and ensure (s)he has informed control of the airframe. To solve this problem, basic human senses were studied in detail. Out of the senses humans possess, the sense of touch is an underused yet an effective channel of information delivery. In the body, the fingers have one of the highest concentrations of nerve endings, and hence feedback in that area is ideal.

Increasing a pilot's situational awareness makes it easier to land safely. The wearable product is a glove designed to ensure the pilot has informed control over the airframe. Based on any deviations from the landing course, vibrational feedback assists the pilot in understanding the course corrections that need to be made. The system is integrated with the instrument landing system (ILS) of any category (I, II, III) airframes, drastically reducing the accidents, and enabling pilots to land safely with a smart use of a non-exhaustive stimulus.

***Keywords:** Haptic feedback, Flight landing, stimuli, situational awareness, course corrections, instrument landing system.*

I. INTRODUCTION

Research shows that final approach and landing constitute four percent of the total flight time [1].Hence making it a critical sector of flying. Aircrafts can basically land in two ways - Manual Landing and Auto Landing. Auto Landing - By definition, it is when the pilot programs the flight computer to carry out the landing automatically while the pilot monitors the aircraft. The autopilot latches onto the ILS broadcast beacon and guides the aircraft onto the runway. Auto land is considered to be very efficient and effective. Despite this, it is estimated that ninety-nine percent landing are done manually [2]. During Manual Landing the pilot remains in control of the aircraft's trajectory and using ILS for reference, guides the plane onto the runway. All along a manual landing the pilot has to control the aircraft, communicate with the ATC (Air Traffic Control), monitor values of airspeed, altitude and possible faults, keep visual contact with runaway and use the ILS system to maintain a stabilized approach, all of this at the same time. This often leads to information overload and thereby stresses anxiety and visual fatigue.

Sensing and manipulation through touch is defined as Haptics [3]. Haptics can be broadly classified in Human, Machine and computer category. Human Haptics deals with the study of human sensing and manipulation through touch. Machine

Haptics deals with design construction and use of machines to replace or augment human touch. Computer Haptics deals with algorithms and software associated with generating and rendering the touch and feel of virtual objects. This project deals with Machine Haptics, where the glove is designed to assist the pilot while landing. Haptic interface also enable manual interactions with virtual environments - haptic gloves expand capabilities of force feedback and let the user feel virtual objects in a much more natural way[4] .This provides a lot of scope for future improvement and implementation of the glove.

II. CONCEPTUAL FRAMEWORK

Glance is designed to work majorly in the landing time period thereby reducing the load on the pilot. It helps increase the pilot's situational awareness which in turn helps in the landing. Glance works on the principle of haptic feedback and helps increase safety of the flight. Haptic feedback in the glove could prompt the pilot to maneuver in a certain way, hence assisting him/her during landing. Glance links with the flight system computer and the ILS system. Deviation from the ideal landing course is calculated via the ILS. From here, Glance gives feedback to the pilot. The haptic feedback in the gloves provides vibrational feedback to the pilot. Feedback is sent to the haptic glove, which makes the haptic actuators mounted on top of each finger vibrate. This helps transmit information to the pilot while landing. Figure I show all the ideas that were considered during the initial stages.

Haptic perception in this case basically uses the principle of tactile sensing to function [5]. Based on these vibrations the pilot can understand what corrections need to be made to the course. Glance is designed from breathable material, padded and rubberized for better grip. The glove has adjustable strap to fit hands of all sizes. ABS (Acrylonitrile butadiene styrene) plastic enclosures will cover the haptic engines.

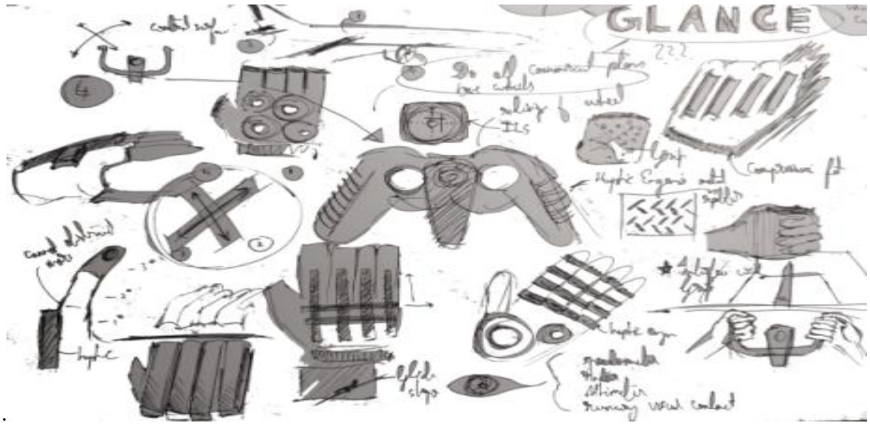

Figure I-Ideation

A. Approach

For the experiment a simple exercise was conducted, with the glove to check its advantages. An experiment was designed which required the player to bounce a ball and keep it from falling down with the help of a joystick/mouse. The player could look at the screen and make out the position of the ball, accordingly operate the joystick in the required direction. In the second phase of the analysis, the player had to wear the glove and play the same experiment. The glove, with the help of haptic feedback made it easier for the player to move the paddle. There were signals sent to varied parts of the glove i.e. each finger separately to tell the user which side the joystick needed to be moved. The time taken during both the phases were noted and compared to check the effectiveness of the glove. Figure II, shows the experiment in process, on the screen.

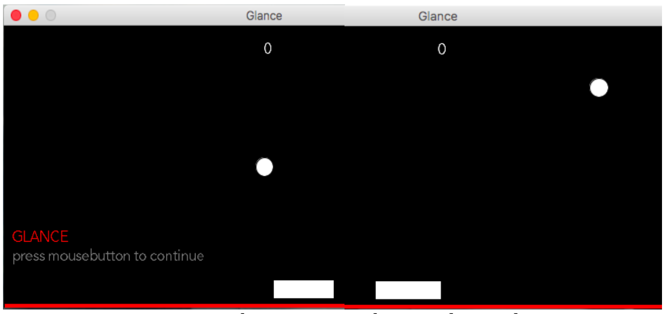

Figure II-The experiment that was designed

III. Alpha Prototype

The Experiment was conducted in three stages-

Stage 1-Design was finalized and required materials were procured.

Stage 2-Materials were used to create a functioning prototype based on requirements.

Stage 3-Trial runs were carried out with prototype and results were noted.

A. Stage 1

The purpose of the alpha prototype is to test if product works in helping intended function. The idea was to design a glove that uses the same principle of haptic feedback to function. The glove was later tested in simulated conditions. Codes were written and tested for the simulated experiment and for the haptic response system. Hardware used for testing are vibration motors (5 in numbers), Arduino Pro Mini (5.5V), Connecting wires. Software used - The Pong Experiment built using Processing, Vibration of motors programmed using Arduino IDE. Figure III, shows Arduino code / Test Code –

```
int thumb = 12;
int index = 10;
int middle = 7;
int ring = 9;
int pinkie = 4;
int x=0;
int t = 20;
void setup()
{
pinMode(12,OUTPUT); pinMode(10,OUTPUT);
pinMode(7,OUTPUT); pinMode(9,OUTPUT);
pinMode(4,OUTPUT);
Serial.begin(9600); Serial.flush();
delay(100);
}
void vibrate(int pin)
{
pinMode(pin, OUTPUT);
digitalWrite(pin, HIGH);
}
```

```
void loop()
{
x = Serial.read();
digitalWrite(12, LOW); digitalWrite(10, LOW);
digitalWrite(7, LOW); digitalWrite(9, LOW);
digitalWrite(4, LOW);
if(x<94 and x>0){
    digitalWrite(4, HIGH);
    delay(t);
}
if(x>94 and x<125){
    digitalWrite(9, HIGH);
    delay(t);
}
if(x==125){
    digitalWrite(7, HIGH);
    delay(t);
}
if(x>125 and x<156){
    digitalWrite(10, HIGH);
    delay(t);
}
if(x>156 and x<255){
    digitalWrite(12, HIGH);
    delay(t);
}
```

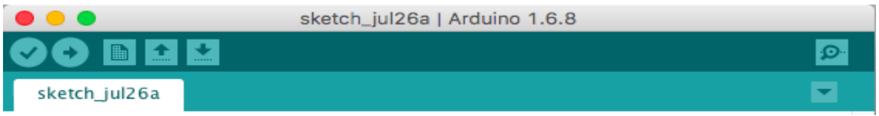

Figure III-The code used to run the Arduino

B. Stage 2

A Physical prototype that works based on the principles of the final product was built.

Discussion-

- Motors were attached to the Arduino and made to vibrate.
- The Experiment was programmed to get in sync with the Arduino, so vibrations are sent out at the right time.
- The position of the Pong and Ball were used in an algorithm to calculate the direction the mouse needed to be moved in.
- Using this algorithm, vibrations were sent out to the correct finger and assisted the player during the experiment.

Haptic feedback sensors i.e. the motors were attached to the glove as shown in Figure - IV. Sensors were programmed to take values from the Experiment and offer feedback in real time. Sensors were connected to the Arduino and worked on Processing through serial communication.

Figure IV-First look of the prototype (Photo: by author)

C. Stage 3

Participants were required to participate in one round of the experiment without the glove and then one round of the experiment with the glove. This was conducted with around 10 people. All the outputs were documented to check the advantages of the glove. Time taken by the participant with and without the glove was catalogued. The performance levels were analysed throughout the experiment. In each round, each player was given five trials without being timed /measured in order to get used to the experiment. This was followed by ten timed chances at the experiment. The best five of results were chosen and its average was considered to plot the graph. Table I, shows the results of the experiments and maps the time (in seconds) each candidate performed better before till the end of experiment. Figure V, shows participants using the glove to perform better and hence last longer. Figure VI, shows the difference in results, when the glove wasn't used and later when it was. The graph clearly shows better performances in terms of higher values when the glove was used.

Table I-RESULTS FROM TESTING THE GLOVE

NAME	WITHOUT GLOVE				WITH GLOVE			
	1	2	3	AVERAGE	1	2	3	AVERAGE
Cand 1	9.2	5.4	4	6.2	10.5	12.8	11.2	11.5
Cand 2	11.6	10.3	9	10.3	20.1	14.5	9.9	14.8
Cand 3	12.3	9.2	7.2	9.5	32	16.2	11.8	20
Cand 4	11.5	6	5.9	7.8	39.8	24	20	27.9
Cand 5	14.2	13.8	8.1	12.03	28.2	22.3	12.1	20.8
Cand 6	6	5.8	4.4	5.4	15	9.6	12.3	12.3
Cand 7	4.5	7.6	11	7.7	10.4	9.8	13.1	11.1
Cand 8	9.4	4.8	4	6.06	13	8.2	7.3	9.5
Cand 9	6.2	9.5	4.7	6.8	8.8	12	10.7	10.5
Cand10	8.1	6.3	5.8	6.7	12.3	8.4	6.3	9.1

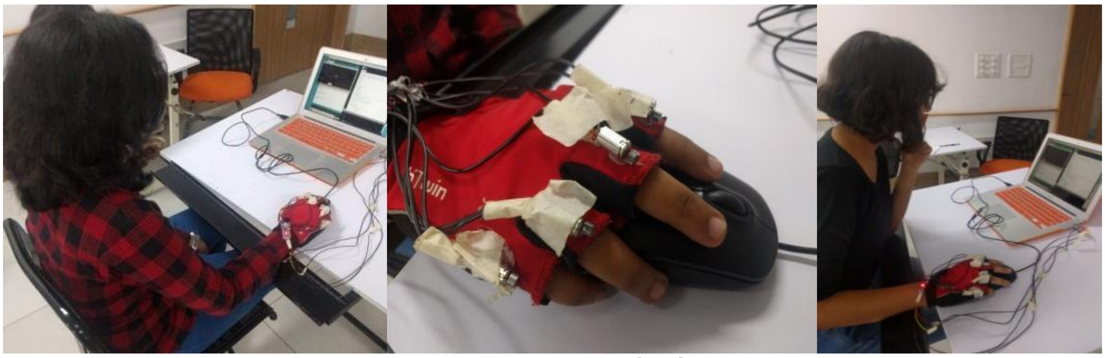

Figure V-Participants testing the Glance
(Taken by author)

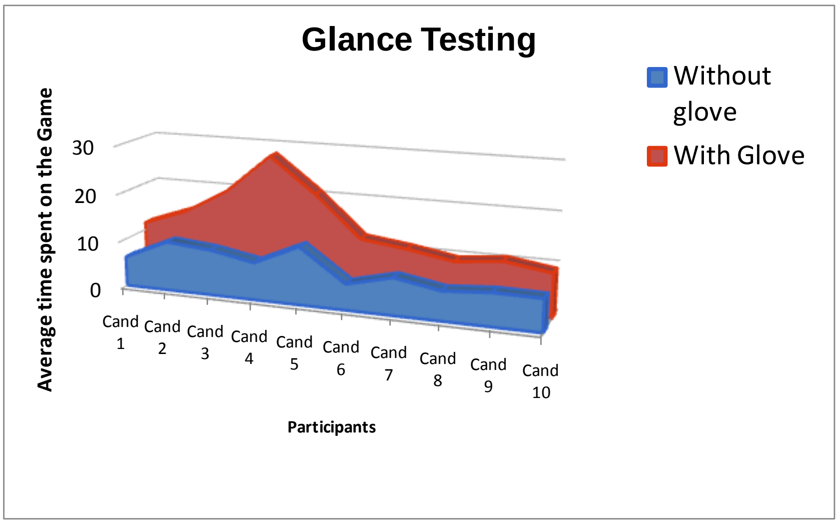

Figure VI-Graph showing difference in results when Glance is used.

IV. Understanding the Results

Glove	To Perform Better
A. Reduces the time taken to respond to visual cues B. Guides the participants hand to effectively hit the ball.	A. Participants need to respond to visual stimuli quickly. B. Participants need to effectively predict where the ball is headed.
Therefore, since participants on an average live for a longer time with the glove on, The glove is successfully helping the participants by fulfilling points A and B mentioned above.	

V. Mapping Experiment to Real Life Scenario

As shown in figure VII, Glance is designed to help a pilot during landing, by showing the corrections that need to be made on the yoke, pedal and throttle to remain in an optimal flight approach envelope. In order to do this, Glance has to predict the corrections to be made on the aircraft, and then guides the pilot to make theses corrections. Prediction and guidance were the criteria that were tested in the experiment, and the performance of the glove was satisfactory, proving that haptic feedback decreases the time taken by a person to react to visual cues and Helping a person perform a movement/action on a controller efficiently. The results can be directly mapped to flight manoeuvring which takes up to thirteen percent of an average flight time. Glance takes in data from the ILS indicator and tells the pilot which direction to move the yoke in to correct a faulty flight path. The feedback is quick; hence the pilot can get back on track in very little time.

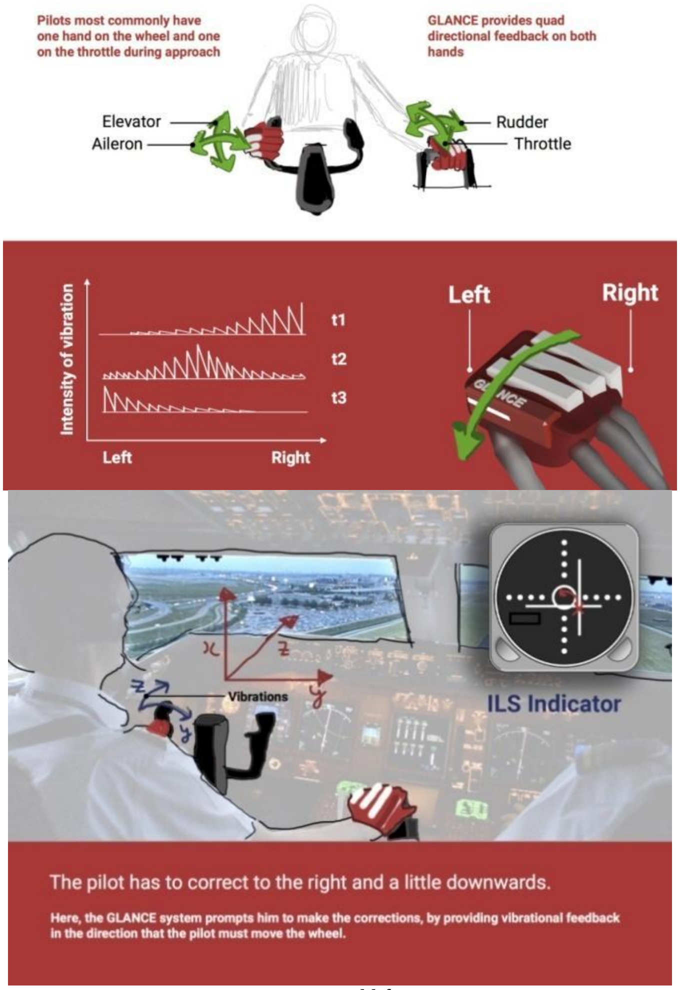

Figure VII-Real life setup

A. Human Factors considered in design

Ergonomics consists of three kinds-Physical, Cognitive and Organizational. Physical ergonomics deals with human anatomical and biomechanical characteristics deals with physical activity. This project falls under cognitive ergonomics. Research from cognitive psychology suggests that haptic channel can provide further valuable way of providing information to the pilot in addition to the auditory and visual channels [6].

The human hand has the highest concentration of nerve ending connecting to the brain. Hence it's a very efficient channel of information. Vibrations excite nerve endings in the skin. Small scale vibrational feedback is distributed amongst the five fingers; interact with the skin and muscle. This provides the user with a sensation of force being applied [7].Figure VIII, shows the fourteen points where the glove provides haptic feedback to the user. The arrows indicate what direction of movement the points will be used to indicate. Six points are used to indicate forward/reverse motions and seven points are used to indicate left/right movement. Complex human behaviour models are being used to generate predictions of operator performance inside more complex operational domains (e.g. process control, aircraft and air traffic control operations), and the need of the hour is to design and validate performance of human behavioural models. [8]

Figure VIII-Points of touch on the glove

VI. CONCLUSION

This research is a preliminary study to find out methods to make landing an easier process from the pilot's point of view. The experiment was conducted in a very elemental setup. The next step is to test out the prototype with more pilots and work on improving the product aspects. To make the product better suited for application and more effective. An in depth evaluation of the materials used and hence best suited for the product would also need to conducted.

References

1. Boeing-Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations (1959–2015)-July 2016.
2. Melody Kramer,Q&A with a Pilot:Just how does Autopilot work?-National Geographic,2013
3. Morris, Hong Tan, Federico Barbagli, Timothy Chang, Kenneth Salisbury- Haptic Feedback Enhances Force Skill Learning,2007.
4. Zhou MA, Teleoperation Mapping TMech-RML Glove-An Exoskeleton Glove Mechanism with Haptic Feedback, 2015.
5. Zheng Wang, Jens Hoelldampf, and Martin Buss, Design and Performance of a Haptic Data Acquisition Glove, 2007.
6. D.Harris (ed.) Human Factors for civil flight deck design (pp.69-102).Aldershot, UK; Ashgate
7. Kim-Phuong L.Vu, Robert W. Proctor, Handbook of Human Factors in Web Design, Second Edition (pp.77), 2011
8. J Sanjog, S.Karmakar, T.Patel, A.Chowdhury, Aircraft Engineering and Aerospace Technology: An International Journal Towards virtual ergonomics: aviation and aerospace, 2015.
9. K.Kulkarni, A. Murgod, V.Parvati-Virtually Controlled Robotic Arm using Haptics.
10. I.Madalina Dumitru, M.Boscoianu, Human Factors Contribution to Aviation Safety, 2015
11. Frank W. Liou, Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development (pp.23), 2007

AUTHOR(S) PROFILE

Ganesh Sadashiv, is an Assistant Professor at Faculty of Architecture and Design, PES University. His primary research interests are Innovative Product Design, Interaction Design, Communication Design and Alternate building technologies. He graduated in civil engineering from Visvesvaraya technological university. He received his master degree from Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, India. He also has an additional qualification, Diploma - Animation Engineering and worked extensively in animation industry on 2D and 3D projects with Autodesk Maya being the area of specialization. He has authored few papers in international conferences and newsletters.

Shruthi Venkat, is a second year design student pursuing Bachelors in Product design. Her passion includes painting, photography and writing. She has a unique way of approaching and solving problems. Design has always been a passion for her and she looks forward to combining her creative outlook and flair for design in her future endeavors.

Aabharan Hemanth, is a second year bachelor of design student - pursuing a degree in Product Design. He enjoys making things, and has long followed the aviation industry. He enjoys working with technology, and blending design with technology to come up with interesting solutions.in 2016, respectively.