HUMAN COMPUTER INTERACTION IN MEDICAL DEVICES

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(GRAD 8)

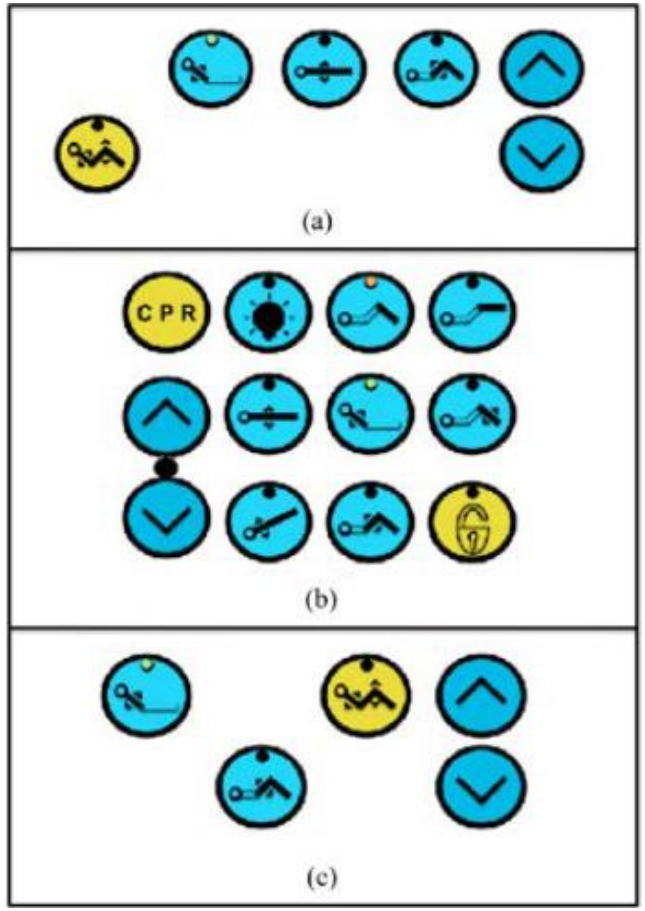
INTRODUCTION : HCI IN MEDICAL DEVICES

- Requirements, testing and use of Medical devices is based on the standards defined for patients' safety.
- HCI in Healthcare improves the safety, ease of use and user satisfaction of medical devices.
- Provides economical solutions by providing heuristic evaluation on the devices
- Optimize the existing system to make it more secure

BACKGROUND/ HISTORY

- Usability problems and human errors
- Direct cause of deaths and injuries
- Reasons : Poorly designed interfaces ,difficulty of use, human errors
- Medical beds: patients getting caught, trapped and entangled in bed
- Infusion pumps: injuries and deaths

CASE STUDY 1- MEDICAL BEDS



Medical bed functions for (a) Patients, (b) Nurses, and (c) Attendants

- Used in General wards, intensive care units, pediatrics
- Three control panels : Patient, Nurse and attendant
- Buttons to change the position of bed and the posture of the patient

Acharya et al. (2010)

EXISTING PROBLEMS IN CASE STUDY 1

01

Senior patients with age range of 70 onwards

02

Patients with no or low visibility or need glasses for reading

03

Children

04

Patients having hand injury/hand fracture

05

Patients who are not comfortable using the keys

PROPOSED SOLUTION

M. HF1048 Comfy I.C.U. Bed, Electric, Five Function With Two Controls

- Two control panels
- Helpful in case of hand fractures and hand injuries
- Mandatory use of hands, Assistance required for special cases

Narang Medical Limited (Product HF1048)

PROPOSED SOLUTION CONTINUED..

- Using HCI in Voice recognition
- Decoding: voice to text to action
- Deals with the information required by audio signals

SPEECH RECOGNITION STEPS

Generation	Signal generation: The process of speaking
Capture	Signal capturing and pre-condition: Digitalization of voice and application of filters to reduce noise and improve clarity.
Extraction	Feature extraction: Process the captured signal by extracting information that is of interest to the system one at a time.
Matching	Pattern Matching: Determine what word or phrase the extracted feature belongs to and concludes on the system output.

Hofman (2014)

USES OF PROPOSED SYSTEM

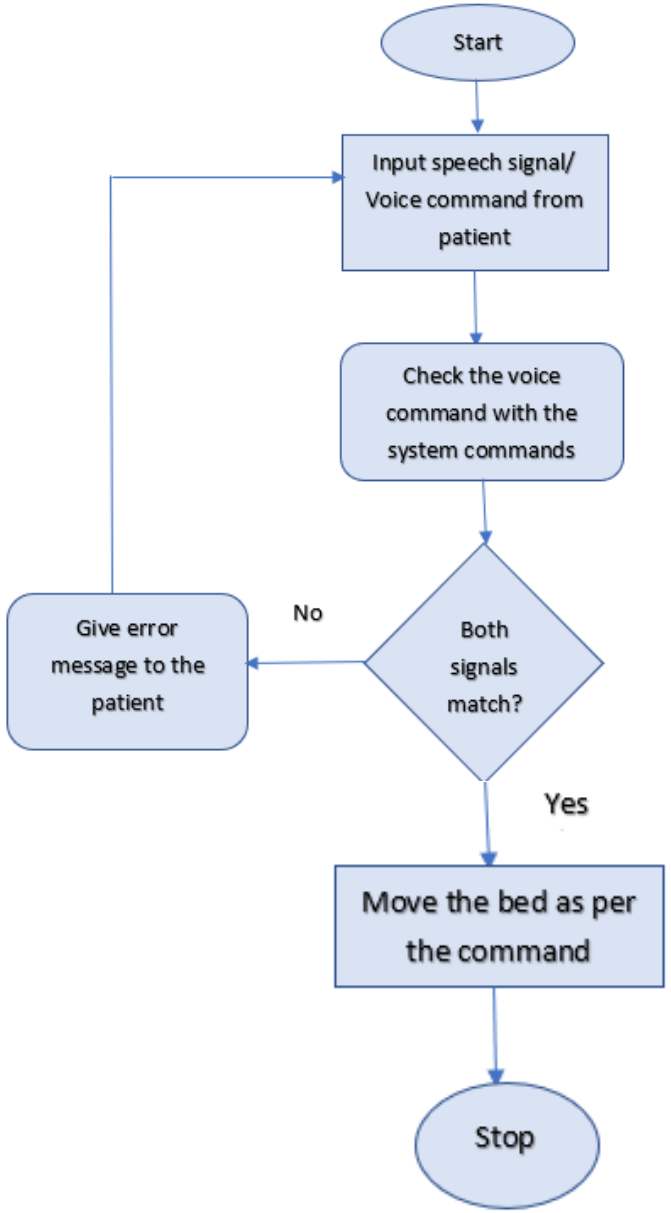
- Availability of voice recognition will allow the patients to give vocal commands for the functionalities provided by the bed
- They can change the posture of their body even if there is no one around in the room
- This feature can be implemented in general wards where attendants or nurses may not be available 24*7
- Maintaining the conventional control panel, addition of this feature can be an influential feature to help the patients
- Patient's reliance on nurses will also be slightly reduced

ALGORITHM FOR VOICE RECOGNITION

The detailed algorithm for voice commands to change the position of the bed:

- Step 1: Record the sound using a microphone for the desired time
- Step 2: Save the recorded sound
- Step 3: During speech recognition, real time speech is recorded; and is checked with the already recorded sound
- Step 4: As soon as sound is matched with the pre-recorded sound, the work allotted to that sound is done

FLOWCHART


Start
Input speech signal/ Voice command from patient
Check the voice command with the system commands
Both signals match?
No
Give error message to the patient
Yes
Move the bed as per the command
Stop

HEURISTIC EVALUATION OF CASE STUDY 1

- Aesthetic design: The patient should easily understand what is to be done to give the voice commands
- Informative feedback: The patients should get the feedback if the Voice commands are not recognized by the system
- Recognition rather than recall: It is used to minimize the user's memory load. The design should be such that patient may not need to remember much operations
- Flexibility and efficiency: Integrating the existing functionality of the control panel with the voice commands. This will enable the reuse of the existing system and provide option for patients to use the voice commands

HEURISTIC EVALUATION CONTINUED..

- Using user's language: As the system is based on voice commands and speech recognition techniques in HCI, the commands embedded in the system should be in user's language
- Good error messages: If the patient is wrong in providing commands it should be prompted in understandable language and using beeps to indicate the incorrect command
- Reversible actions: Even though the system is based on voice commands, user should be able to reverse the action done. Option of Undo to be in the original position

CHALLENGES IN CASE STUDY 1

- Execution time: Panic and confusion results in cluttering of commands causing the system to miss commands
- Wait time: Wait time in between commands needs to be optimized for fluidic operation of the system
- Clarity and Noise: Overcome noise to avoid missing a command.
- Language: Multilingual user-voice interface for patients with different first language. Adding language options is a good option to overcome this issue, however it adds another complexity to the problem

CASE STUDY II – INFUSION PUMPS

- Device for delivering fluids to patient's body in a controlled and measured proportion
- Fluids: hormones, antibiotics, chemotherapy drugs, and pain relivers
- Working of the device depends on software which programs and controls the delivery of the fluid
- Smart infusion pumps have alerts (alarms) to indicate the blockage in the tube

EXISTING PROBLEMS IN INFUSION PUMPS

Problems are based on the alarming system used in the infusion pumps

- Audibility of alarms
- No centralized alarm system
- Same alarms/sounds for different problems
- False alarms (technically correct/incorrect and clinically relevant/irrelevant)

PROPOSED SOLUTION

Using centralized alarm system

Classifying alarms based on criticality of the problem

Using the data logging system by the general wards

HEURISTIC EVALUATION OF INFUSION PUMPS

- Visibility : Information should be properly displayed on screen. The indication of the nutrients and quantity should be displayed
- Undo: Users should be able to reverse the actions. The users should be able to modify the data and able to switch configurations
- Language: As the pumps include text interface, the intended users should have the same language of the system

HEURISTIC EVALUATION OF INFUSION PUMPS

- Error: The errors can be indicated on the screens and should use alarming system on the centralized machine.
- Flexibility: Alarms are classified based on the criticality of the event/issue.
- Feedback: Users should be given accurate and informative feedback.

CHALLENGES IN INFUSION PUMPS

- Software problems : Error messages should be handled and every message should be treated well
- Human factors : Avoid confusion due to ambiguous instructions. Pump labels or components become damaged under routine use and are susceptible to improper treatment. False alarms end up reducing users' sensitivity to all alarms
- Broken/damaged components: Avoid mishandling of the device, prompt detection of malfunctioning components, save components from voltage surges
- Battery failures: Premature battery failure is unexpected and very harmful for the smooth operation of the device

CONCLUSION

- Many of the applications can be integrated together to provide the easy to use system for a user.
- Building the system based on HCI principles ensures economical system.
- Voice recognition will help solve multiple issues related to the operation of medical devices like the bed.
- Addition to the voice recognition can be the gesture recognition which has proven to be more useful for all the physically challenged persons.
- Human errors cannot be totally eradicated but limiting them can be achieved by overcoming the aforementioned challenges.
- Classifying the emergency alarms would relieve anxiety in patients and centralized system will additionally ease the workload of the hospital staff.

REFERENCES

- Acharya, C., Thimbleby, H., Oladimeji, P., (2010) Human Computer Interaction and medical devices, ISBN: 978-1-78017-130-2
- Johnson, T.R., Thimbleby, H., Killoran, P., Diaz-Garelli J.F. (2015) Human Computer Interaction in Medical Devices. In: Patel V., Kannampallil T., Kaufman D. (eds) Cognitive Informatics for Biomedicine. Health Informatics. Springer, Cham, ISBN: 978-3-319-17272-9
- Zhang, J., Johnson, T.R., Patel, V.L., Paige, D.L., Kubose, T., (2003) Using usability heuristics to evaluate patient safety of medical devices, Journal of Biomedical Informatics, Volume 36, Issues 1–2, Pages 23-30, ISSN 1532-0464
- Human Computer Interaction (HCI), User experience (UX) topic overview/definition, 2018, Retrieved from: https://www.interaction-design.org/literature/topics/human-computer-interaction
- Rathore, P., Khatri, A., Pushpad, A., Jain, S., (2016) Demonstration of Visual-based and Audio-based HCI system, International Journal of Research in Engineering and Technology, Volume 5, Issue 04, eISSN 2319-1163
- Sowmya, D., (2013), Human Computer Interface, Retrieved from: https://www.slideshare.net/gsantosh031/1204-hci-new
- Hofmann, N., (2014) Speech recognition for human computer interaction, Ubiquitous computing seminar, Student Report, ETH Zurich, Retrieved from: https://www.vs.inf.ethz.ch/edu/FS2014/UCS/reports/NiklasHofmannn_SpeechRecognition_report.pdf

REFERENCES

- The U.S. Food & Drug Administration, Example of Reported Infusion Pump Problems (2017), Retrieved from:
- https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/InfusionPumps/ucm202496.htm#1
- The U.S. Food & Drug Administration, Infusion Pumps (2016), Retrieved from:
- https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/InfusionPumps/
- Graham, M.J., Kubose, T.K., Jordan, D., Zhang, J., Johnson, T.R., Patel, V.L., (2004), Heuristic evaluation of Infusion pumps: implications for patient safety in Intensive Care Units, International Journal of Medical Informatics, Volume 73, Issues 11-12, Pages 771-779, ISSN 1386-5056.
- Santos, M., Hoh, T., Soliven-Llaguno, J., (2013), Returns to Patient Safety Evidenced through Infusion Data, Canadian Journal of Nursing Informatics, Volume 7 No. 3&4.
- Lin, Y.L., Guerguerian, A., Laussen, P., Trbovich, P., (2015), Heuristic Evaluation of Data Integration and Visualization Software Used for Continuous Monitoring to Support Intensive Care: A Bedside Nurse's Perspective, Journal of Nursing & Care, ISSN 2167-1168