The design specification report for personal trackers and emergency wrist band

A- DESIGN GUIDELINES FOR PERSONAL TRACKER AND EMERGENCY WRISTBAND

As the there is no ISO and IEEE standard specialized for wearable technologies, these design guidelines have been achieved via a systematic literature review, as well as the ISO standard on Ergonomics of Human System Interaction (ISO 9241-210:2010).

General

0.The device should be designed based on a thorough understanding of context of use and potential usage scenarios (Motti & Caine, 2014; Karahanoglu & Erbug, 2011; Siewiorek et al., 2008).

User comfort

1.The device should be designed in a way that it does not reduce users' comfort. This is because feeling discomfort and stress due to wearing an electronic device can negatively influence the usability of this device (Michaelis et al., 2016; Motti & Caine, 2014; Cho, 2010; Knight et al., 2006).

2. The device should not restrict movement of the user (Motti & Caine, 2014; Dunne, 2004; Knight et al., 2006; Gemperle, 1998). For instance, as flexible materials do not restrict movement, such materials are preferable particularly for the device body and attachments (Dunne, 2004; Knight et al., 2002).

3. The device should be easily worn and taken off (Knight et al., 2006).

4. The device should be adjustable to different body sizes (Lowens et al., 2015; Motti & Caine, 2014; Dunne, 2004; Gemperle, 1998)**.** In order to achieve this goal, designers can use adjustable straps.

5. The device should be lightweight and small so that it does not restrict users' movement and disturb their balance (Tharion et al., 2007; Knight et al., 2006, Knight et al., 2002; Gemperle, 1998). Smaller devices and using sensors placed on stable parts of human body (Figure 1) would less likely to decrease user comfort (Hoof, Van & Penders, 2013). In this respect, accessories like wrist watches, wristbands and vest can be used when designing wearable devices for the workplace (Awoluousi vd. 2018).

Placement on the body

6. The device should be placed on the body in an unobtrusive manner (Gemperle, 1998). When choosing a place on the body, designers should prefer

- spots that do not vary significantly across people who have different body types,
- places that provide a bigger surface area,
- places that can remain stable when the body is moving.

Note: Please see also Item 11 for this guideline.

7. The device should be positioned on the body based on the type of task users are responsible for as well as their posture while performing this task (Thomas et al.,1998). When choosing a place on the body, designers should prefer,

- fore arm and wrist for general purpose (Figure 1-c),

- thigh for people who usually sit during work (e.g. emergency personel) (Figure 1-f),
- upper arm region for people who usually lie down while working (e.g. infantry)(Figure 1-b).

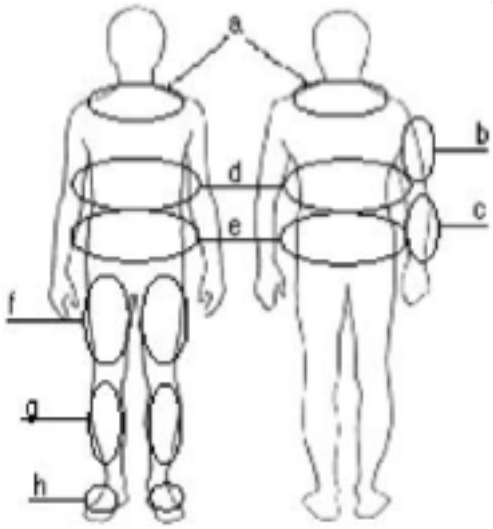

Figure 1. Body parts that wearable devices can be placed on

8. The device should be closer to the body part providing measurable data. Awolisi et al., 2018). For example, a device aimed at measuring heart rate should be closer to chest for accuracy.

9. The designers can choose the clothes and devices that the users are already wearing to maximize comfort and adoption (Awoloisi et al., 2018). For example, safety vest, wrist watch, shoe or wrist bands can be preferred for factory workers.

10. The device should be within the perceptual body space to be perceived as a part of the users' body (Figure 2). (Gemperle, 1998). (The concept of "proxemics" can be further examined to advance on this issue).


Figure 2. The space perceived as one part of the body by the human brain

Visual design

11. The visual design of the device should be suitable for the aesthetic preferences of the users as well as the visual unity of the environment (Motti & Caine, 2014; Knight et al., 2006;

Gemperle, 1998). For example, Angelini et al., 2013) found that users are inclined to use wearable devices which do not have a medical look but have a visually attractive form.

Note: This guideline becomes more important when the design team can not address guideline 1.

Attachment type

12. The accessories used to attach the device to the body should have a tight-fitting form Gemperle, 1998).

Form and material

13. The form of the device should be compatible with human body; concave inside convex outside (Motti & Caine, 2014; Lin & Kreifeldt, 2001; Baber et al., 1999; Gemperle, 1998).

14. The device parts touching the body should have breathable material (Gemperle, 1998).

15. The materials should be compatible with environmental conditions such as moisture, temperature and friction (Lowens et al., 2015; Motti & Caine, 2014; Awalonisi et al., 2018)

User interface

16. The device interface should be easy to use (Lowens et al., 2015; Motti & Caine, 2014; Cho, 2010; Siewiorek et al.,, 2008; Knight et al.,2006).

17. The interface should not attract the users' attention while performing a regular work related task (Motti & Caine, 2014; Siewiorek et al., 2008; Knight et al., 2006).

18. The device should give option to the users regarding whether to share the personal data with third parties (Awolisi et al., 2018; Schall et al., 2018; Motti & Caine, 2014; Oliver et al.,2007).

19. The feedback and notivafictiaons ent via the device should not create a distraction and not disrupt others (Motti ve Caine, 2014; Lee ve Lim, 2011; Hanson ve Ljungstrand, 2000).

20. The device should have a durable battery (Awolisi et al., 2018.)

B- USER REQUIREMENTS FOR THE PERSONAL TRACKER AND EMERGENCY WRIST BAND

Contextual conditions/problems

Environmental conditions

- Areas inside the factory are difficult to enter, there can be narrow, oily and dirty areas.
- Since the factory is very large, each BAKUT member controls their own area. They are not as acknowledged in other areas.
- The most critical areas are oil chambers. These rooms are maze-like. It may be difficult for teams to find a person and extract.

Equipment conditions

- There are some accessories that change according to seasonal factors. For example, the vest is changeable. But shoes and helmets do not change.
- During the fire suppression, the BAKUT members staying outside are wearing the blue emergency vest while the members who will intervene in the fire wear fire fighting vest.
- Fire fighting outfit is too heavy. Wearing and removing is a very serious problem. For example, the oxygen tank on the back is attached via help of another person.

Emergency Intervention conditions

- During extraction, the heart rate is controlled first, then the person is extracted from the environment. Then the victim is transferred to medics.
- In the case of an emergency, it is unclear who is in the danger zone. It is guessed by looking at the work-shift tables. The intervention team understands whether someone is in or not after getting inside.
- If there is a BAKUT member available at the time of the incident, things get a lot easier. Otherwise, it is necessary to find someone who knows the area. Therefore, they are trying to distribute the members of BAKUT homogeneously.
- BAKUT team leader executes the task distribution of the BAKUT members only after everyone reaches to emergency meeting area.
- It is not known who's been there until team leader gets there. Number of BAKUT members in the factory, where are their stations, these information cannot be understood before reaching the emergency area. Shift supervisors needed to be called individually to find members available. This causes a loss of time and makes planning difficult.
- During the fire intervention, the communication between personel inside and outside and among personel inside is problematic. Fire suit mask makes this communication even more difficult. In some cases, the person inside has to go out and inform others about the situation, then go back in.
- As the panic spreads during unplanned drills, existing methods that require time and mental effort, such as the WhatsApp groups, cannot be used.

Conditions for the current emergency situations

- In case of emergency, the news flow is: team leader - security - emergency siren - BAKUT intervention.

  > “There are different lines. Each line has a team leader. In the event of an emergency, security is notified, they ring safety emergency siren. Emergency commander is informed. (Then) We go to the emergency area as a team.” P1

- Currently there are systems used to determine the position of personel in the building room.

  > “We have a system in the oil chamber that tells us where a person is. With the repeaters inside, we can see where a person is in which (time) range. There are concrete blocks. There are tanks, If you don't look there you can’t know there is a person there.” P2

- There is already a device used to measure the vital signs of the guard working on the galvanization line.

  > “(Only) One person stays on that shift over the weekend. Because he is the only one, there is a system similar to the one in oil chamber. In case of staying still, falling it sends an alarm to its section manager. Also provides route data. For example the system in oil chamber sends a sms to me, something happened. Manager receives an alarm, siren rings etc.” P1

- There may be misinformation due to errors that occur in the LCD displays.

  > “Communication problem has become a problem. For example in our fire case we have LCD counters indicating the event location's code. It was showing wrong, we went to the wrong place. It took quite a while. “P4

Desired device features

Placement on the body

- The placement should not intervene with existing equipment. For example, the most suitable place on the fire fighting vest is the chest area. (Related Guide: 7)
- Belt-mounted versions are preferred for personal tracking devices. Because the workers can walk out during the breaks, without taking the equipment other than belts. (Related guide: 2, 9)

- The health wristband's appearance as a bracelet is appreciated. It is thought to be helpful to create a habit because it can be associated with wearing a watch. (Related guide: 2, 9)
- Use as a necklace is not preferred for personal tracking devices and health wristbands. (Related guide: 2)
- Workers prefer using their everyday accessories (watches, wristbands and belts) for personal tracking devices and health wristbands. (Related guide: 9) -This feature was preferred by 3 people.-
- It is preferred that device is not plugged/unplugged to anywhere. (Related Guide: 3)

Device body and material

- The device body is expected to be durable. (Related guide: 15)
- The device body is expected to be light. (Related guide: 5) -This feature was requested by 3 different people.-
- The device should not create heat where it is placed. (Related guide: 14)
- The materials of the device is expected to withstand the environmental conditions (humidity, temperature). (Related guide: 15)

Visual design

- The exterior of the device should be thin and elegant. (Related guide: 11)
- The device should not look like a toy. Designs with soft lines and vibrant colors create this perception. Example #1 in Figure 4. (Related guide: 11)
- The external appearance of the device should give the impression that it is durable. (Related guide: 11)
- The device is required to appear high-tech. (Related guide: 11)

Device functions

- An emergency button is required in the personal tracking devices.
- During the fire suppression, the emergency team wants to get feedback on their vital signs.
- Having screens on tracker, wristband and vest is preferred because it is easier to find detailed information. The user opinions diverge on this context. Some think they don't need to see the information in the emergency situation, so there is no need for a display on the devices. However, it is considered that the placing the screen will reduce the durability of these devices.
- The emergency vest is required to be able to give information about the environment without entering.

Selected bibliography

1. Awolusi, I., Marks, E., & Hallowell, M. (2018). Wearable technology for personalized construction safety monitoring and trending: Review of applicable devices. *Automation in Construction*, *85*, 96-106
2. Baber, C. (2001). Wearable computers: a human factors review. *International Journal of Human-Computer Interaction*, *13*(2), 123-145.
3. Dvorak, J. L. (2007). Moving wearables into the mainstream: Taming the Borg. Springer Science & Business Media.
4. Dunne, L. (2004). The design of wearable technology: addressing the human-device interface through functional apparel design.
5. Gemperle, F., Kasabach, C., Stivoric, J., Bauer, M., & Martin, R. (1998, October). Design for wearability. In *Wearable Computers, 1998. Digest of Papers. Second International Symposium on* (pp. 116-122). IEEE.
6. ISO 9241-210:2010. Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems. https://www.iso.org/standard/52075.html

7. Karahanoğlu, A., & Erbuğ, Ç. (2011, June). Perceived qualities of smart wearables: determinants of user acceptance. In *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces* (p. 26). ACM.
8. Knight, J., Deen-Williams, D., Arvanitis, T., Baber, C., Sotiriou, S., Anastopoulou, S., & Gargalakos, M. (2006). Assessing the Wearability of Wearable Computers. *2006 10th IEEE International Symposium on Wearable Computers*, 75-82.
9. Knight, J. F., Baber, C., Schwirtz, A., & Bristow, H. W. (2002, October). The Comfort Assessment of Wearable Computers. In *iswc* (Vol. 2, pp. 65-74).
10. Lowens, B., Motti, V., & Caine, K. (2015, March). Design recommendations to improve the user interaction with wrist worn devices. In *Pervasive Computing and Communication Workshops (PerCom Workshops), 2015 IEEE International Conference on* (pp. 562-567). IEEE.
11. Michaelis, J. R., Rupp, M. A., Kozachuk, J., Ho, B., Zapata-Ocampo, D., McConnell, D. S., & Smither, J. A. (2016, September). Describing the user experience of wearable fitness technology through online product reviews. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 60, No. 1, pp. 1073-1077). Sage CA: Los Angeles, CA: SAGE Publications.
12. Motti, V. G., & Caine, K. (2014, September). Human factors considerations in the design of wearable devices. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 58, No. 1, pp. 1820-1824). Sage CA: Los Angeles, CA: SAGE Publications.
13. Motti, V. G., & Caine, K. (2014). Understanding the wearability of head-mounted devices from a human-centered perspective. *SEMWEB.*
14. Schall Jr, M. C., Sesek, R. F., & Cavuoto, L. A. (2018). Barriers to the Adoption of Wearable Sensors in the Workplace: A Survey of Occupational Safety and Health Professionals. *Human factors*, *60*(3), 351-362.