The summarized guidelines for accessibility requirements in Human-Robot Interaction

The following guidelines are implemented based on accepted accessibility guidelines, standards and recommendations in Human-Computer Interaction, such as, WCAG 2.0, BBC, FUNKA NU, IBM, WAI-ARIA, and PUX [1-6]. The guidelines can be used by developers and designers of social assistive robots, where the context of use is one user interacts with one robot.

Perceivable			
	Requirement	**Description**	**How to achieve it**
1	**Multiple modalities for interaction**	User can operate the robot using different channels for input and output.	a) Provide multiple modalities for interaction. (for examples, see **annex 1**) b) Verify that all functions are accessible via keyboard, virtual keyboard, mouse, tactile displays, voice (Automatic Speech Recognition and Text To Speech techniques) or gestures (according the interaction modalities chosen).
2	**Color and Contrast**	Color is not the only way to distinguish keys, controls and labels or to convey information, and it is easy to distinguish foreground from the background.	a) Make sure that color is not the only way to indicate hardware controls, keys and labels of the robot. This also applies to software widgets (buttons, labels, etc.) or for information displayed on the robot. (for examples, see **annex** 1) b) Careful use of luminosity, contrast, and background audio. WCAG 2.0 (guideline 1.4)
3	**Location of hardware and software components.**	User can easily perceive and access robot's interfaces (hardware and software) components.	a) Make sure the display of visual information is visible to people who are of short stature or seated in wheelchairs. Place interface components in a perceivable and accessible place, for example, place hardware buttons in the middle of robot's body. b) Design consistently, and group related elements together. For example, place software buttons and links horizontally, vertically or on a grid, and important objects at the top of the interface and the less important objects at the bottom. c) Avoid unnecessary information and objects. Use images only when necessary. Funka Nu (43.content) and BBC guidelines (HTML Accessibility)
4	**Alternatives for non- text elements**	All non-text interface elements on robot's display and all spoken information must have accompanying text or synchronized alternatives for multimedia elements.	a) Provide captions, description or labels for all non- text interface elements. b) For prerecorded and live multimedia, provide captions, audio descriptions, or sign language. For robot voice, provide text or sign language. WCAG 2.0 (guideline 1.1, 1.2).

5	**Blinking components**	For any blinking component on robot's interface (lights, display contents, etc.) the blinking stops after a certain period, or can be switched off by user.	- Provide a mechanism to allow user to stop blinking, or specified the blinking times for the content to be a fixed number. WCAG 2.0 (guideline 2.2.2)
6	**Flashing visual content**	Avoid flashing components on the robot's interface that are known to cause seizures.	- Any flashing component should not exceed three flashes in one second. Red flash should be avoided. WCAG 2.0 (guideline 2.3)
7	**Displays**	Separation of content and presentation.	a) Make sure presentation and structure of the content is determined programmatically in code, so it can be rendered appropriately on different devices and for different audiences. WCAG 2.0 (guideline 1.3) b) The meaning of colored information should also be clear without color through the context for example. c) Do not rely on shape, size, location or color to represent the meaning of user interaction elements. Add a text label as well. WCAG 2.0 (guideline 1.3)
		Large clickable areas, icons and objects on the interface are familiar and should appear clickable.	- Use familiar icons, and design objects with clickable appearance and large clickable areas. Funka Nu (25. Layout and design)
		User can invert the screen contrast (dark text on a light background, and vice versa).	- Provide a setting for invert colors or contrast.
		User can change font type and size, and zoom in or out on the interface.	a) Provide a setting for change font type and size within a minimum text size. b) Make sure user can zoom the interface up to 200%. BBC guidelines (HTML accessibility)
8	**Assistive Technology and web interfaces**	User can use assistive technology to interact with the robot, such as screen reader, braille keyboards, etc.	**For web interfaces** : a) Design accessible patterns and widgets based on WAI-ARIA, by defining roles, properties and states of the widgets in the code. (for examples, see **annex 1**) b) Identify the organization and structure of a web page by using ARIA landmark roles in the code, such as headings and regions. c) Provide keyboard navigation in the code based on WIA-ARIA for UI objects and events. (for examples, see **annex 1**) WIA-ARIA best Practices **For hardware:** d) Provide industry standard ports for alternate input and output device, e.g., assistive tools.

Operable			
9	**Hardware controls and physical operation**	User can operate all hardware and physical controls with one hand and minimum dexterity	- Design the input devices, such as, keyboards, remote controls (including the joysticks, buttons, etc.) so the user can operate them with one hand and minimum dexterity. (for examples, see **annex 1**)
10	**Keys, Keyboards and Keypads**	User can verify the status of locking or toggle keys visually, through touch or sound, or tactically.	- Provide visual, auditory or tactile feedback to verify the status of locking or toggle keys. (for examples, see **annex 1**)
11	**Navigating on displays**	Facilitate navigation process while interacting with robot's display.	- Provide methods that help the user to navigate, find content and determine where s/he is in a structure. (for examples, see **annex** 1)
12	**Time**	Time does not affect users' ability to finish any interactive task with the robot, s/he has started.	- Allow user to control the time limits, turn off, adjust or extend the time limit, except when time is an essential part of activity or real-time event.
Understandable			
13	**Predictable interaction**	Interaction with the robot is consistent and predictable.	a) Use a simple and familiar interaction and navigation mechanism. b) A change in operation of the robot should preferably be initiated by the user.
14	**Errors, Help and feedback**	User can review and correct interaction information before submitting, this can avoid errors. User can at all times query what the robot the doing or processing.	a) Provide a clear mechanism controlling the robot and reviewing commands before execution. (for examples, see **annex 1**) b) Design robot's system to detect and explain errors to the user, and where possible explain how to correct them. (for examples, see **annex** 1) c) Inform the user about progress status during their interacting with the robot.
15	**Natural voice**	Robot's voice should be clear and natural, user can choose robot's voice s/he prefers, and adjust/ set the voice volume.	a) Provide the robot with a set of different clear and appropriate voices and allow user to choose the voice that matches his/her hearing abilities or preferences. b) Where possible, allow the user to select a preferred voice accent. c) Provide a mechanism to allow user to adjust the robots' voice volume.
16	**Displays**	Predictable UI components and functionality.	- Use familiar user interface components and widgets. (for examples, see **annex** 1)
		(Readability) Text on the robot's display should be legible for user.	a) Provide additional information for unusual words or phrases, avoid the use of abbreviations. b) Make sure the line length does not exceed 70 characters. c) If necessary, identify a specific pronunciation of words to give them the correct meaning. d) Ensure the readability of all text (http://www.readabilityformulas.com/freereadability-formula-tests.php)

General			
17	**Adopting user's interaction preferences**	User adjusts/sets the interaction settings of the robot, preferences are stored.	- Design the robot to adopt to and store the users' interaction abilities, preferences and settings. (for examples, see **annex 1**)
18	**Reachable Human support**	User can easily ask for human help or support.	- Design the robot with a mechanism for calling human support or help. (for examples, see **annex 1**)

Annex 1

1. **Multiple modalities for interaction:**
   a) **For example**: users with visual disabilities can operate the robot using keyboard or voice, users with hearing or speech disabilities can operate the robot using alternatives to speech input, or people who are tetraplegic can use vocal input, among others.

2. **Color and Contrast:**

   a) **For example**: providing different visual means, such as, different shapes for hardware keys and controls, and text to describe the function of software components and widgets (buttons, labels, etc.) on the robot's display.

8. **Assistive Technology and web interfaces:**

   a) **For example**: in the code, mark-up is used to describe the type of the widgets, such as "button" or "tree item". Moreover the developer can describe the state of the widgets using properties, such as "checked" for check boxes.

   c) **For example**: when the focus is on a closed node in a tree view widget, then the Right arrow opens the node without moving the focus.

9. **Hardware controls:**
   For example: provide extra-large buttons which are easy to press, with non-slip texture.

10. **Keys, Keyboards and Keypads:**
    For example: use a small light for visual feedback, e.g., Caps Lock. A binary position, e.g., depressed, not depressed for the tactile feedback.

11. **Displays:**
    For example: enable the user to bypass the repeated content viewed on robots' display, and provide descriptive titles, headings and labels for any content on the page.

14. **Errors, Help and feedback:**

    a) **For example**: give the user options to fill the required field (checkboxes, radioboxes, etc.), and provide a mechanism, a button control for example, where the user can press it after filling the required fields.

b) **For example**: if the user makes an error during the interaction with the robot, provide the user with error messages that can be expressed through the multichannel output and considering the user-selected interaction model, and allow him/ her to check and reconfirm the submitted interaction information.

16. **Displays:**

For example: use the integrated objects that is contained in the operating system instead of implementing new components with the same functionality. For example, use the PLAY ▶ symbol instead of designed a new symbol.

17. Adopting users' interaction preferences:

For example: adapting the mode of interaction or the robot's voice volume and font size to the user's preference.

18. Reachable Human support:

For example: a robot is used as a medical assistant in a hospital, at any time while interacting with the robot, patients can call the doctor/nurse by pressing a button on the robot's display.

References

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