The following is a list of heuristics to which problems within the VE can be attributed. Problems may relate to more than one heuristic, in this case the most relevant heuristic is stated with a note detailing further relevance to other heuristics.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Guideline** |  |  | **Explanation** | |
|  |  |  |  |  |  |
| Natural engagement | | | Interaction should approach the user’s expectation of interaction | | |
|  |  |  | in the real world as far as possible. Ideally, the user should be | | |
|  |  |  | unaware that the reality is virtual. Interpreting this heuristic will | | |
|  |  |  | depend on the naturalness requirement and the user’s sense of | | |
|  |  |  | presence and engagement. | | |
|  | | |  | | |
| Compatibility with the user’s | | | The VE and behaviour of objects should correspond as closely as | | |
| task and domain | | | possible to the user’s expectation of real world objects; their | | |
|  |  |  | behaviour; and affordances for task action. | | |
| Natural expression of action | | | The representation of the self/presence in the VE should allow | | |
|  |  |  | the user to act and explore in a natural manner and not restrict | | |
|  |  |  | normal physical actions. This design quality may be limited by | | |
|  |  |  | the available devices. If haptic feedback is absent, natural | | |
|  |  |  | expression inevitably suffers. | | |
| Close coordination of action | | | The representation of the self/ presence and behaviour manifest | | |
| and representation | | | in the VE should be faithful to the user’s actions. Response time | | |
|  |  |  | between user movement and update of the VE display should be | | |
|  |  |  | less than 200 ms to avoid motion sickness problems. | | |
|  | | |  | | |
| Realistic feedback | | | The effect of the user’s actions on virtual world objects should | | |
|  |  |  | be immediately visible and conform to the laws of physics and | | |
|  |  |  | the user’s perceptual expectations. | | |
| Faithful viewpoints | | | The visual representation of the virtual world should map to the | | |
|  |  |  | user’s normal perception, and the viewpoint change by head | | |
|  |  |  | movement should be rendered without delay. | | |
| Navigation and orientation | | | The users should always be able to find where they are in the VE | | |
| support | | | and return to known, preset positions. Unnatural actions such as | | |
|  |  |  | fly-through surfaces may help but these have to be judged in a | | |
|  |  |  | trade-off with naturalness (see heuristics 1 and 2). | | |
| Clear entry and exit points | | | The means of entering and exiting from a virtual world should be | | |
|  |  |  | clearly communicated. | | |
| Consistent departures | | | When design compromises are used they should be consistent | | |
|  |  |  | and clearly marked, e.g. cross-modal substitution and power | | |
|  |  |  | actions for navigation. | | |
| Support for learning | | | Active objects should be cued and if necessary explain | | |
|  |  |  | themselves to promote learning of VEs. | | |
|  | | |  | | |
| Clear turn-taking | | | Where system initiative is used it should be clearly signalled and | | |
|  |  |  | conventions established for turn-taking. | | |
| Sense of presence | | | The user’s perception of engagement and being in a ‘real’ world | | |
|  |  |  | should be as natural as possible. | | |

Once problems have been assigned to a heuristic the severity of the error is ranked with reference too the heuristic. The ranking system is as follows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Ranking** | |  | **Meaning** | |
|  |  |  |  |  |  |
| Severe | | | The problem encountered would make it impossible to complete the task | | |
|  |  |  | successfully. | | |
| Annoying | | | The problem would disrupt the user’s task but most users would learn how to cure | | |
|  |  |  | the error given an explanation, and some might find a work-around with time. | | |
| Distracting | | | The problem would disrupt the user’s tasks but most users would discover the fix | | |
|  |  |  | relatively quickly given a hint. | | |

An additional step is introduced to expert evaluation for VR; a technology audit that establishes the baseline of what the VE can reasonably be expected to deliver, given the interactive devices present in the application. The technology audit is carried out in the familiarisation period when the evaluator explores the VE and notes the presence or absence of features in the following categories, and any problems associated with them.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Features | | | Explanation | | |
|  |  |  |  |  |  |
| Operation of the user’s  presence | | | How the user may be represented in the virtual world. For example, by a hand or a whole body avatar. The user’s presence and how it is controlled can cause problems since they provide imperfect rendering of the user’s actions. Suitability of the presence needs to be judged in relation to the user’s task. For simple navigation, no presence may be necessary; for manipulations, however, a virtual hand is usually necessary | | |
| Lack of haptic feedback | | | Problems caused by absence of haptic feedback may be observed with complex manipulations and physical tasks. | | |
| Interactive techniques | | | VEs may implement interactive techniques to select distant objects by ray-casting. This can be taken further by having nearby objects automatically jump into the user’s hand. These effects can cause usability problems when they are poorly designed. | | |
| Realistic graphics | | | VEs applications are normally not rendered in photorealistic detail. Although some evidence suggests that people can perform tasks naturally without detailed visual representations, graphical detail will be important for information displays and for tasks when the system environment is visually complex. | | |