Designing Optimal Viewpoints in Technical Illustrations

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Abstract
Technical illustrations are important for understanding spatial positions in a 2D environment. This paper demonstrates that illustrations that show a performer's point of view (body-centered and seen as following the performer from the perspective of the performer's body) is equally easy or difficult to mentally animate and visualize when compared to spectator's point of view (object-centered seen as facing the audience directly). Specifically, it is difficult to perform mental animation for spatial movement of body positions from text-based explanations only. The paper argues that canonical viewpoints (allow viewers to see several surfaces of objects simultaneously) and those across the display plane (views that allow important parts of the objects to be visible) could be easier to comprehend when compared to viewpoints into the display plane (views that obscure important parts of objects). However, an optimal combination of camera angles, type and complexity of the task, body positions shown, and individual's ability for mental rotation are important indicators of how a task could be perceived based on 2D visualization.

Keywords: Mental Rotation, Technical, Illustrations, Design, Imagery, Movements

Introduction

Understanding complex technical illustrations for a physical procedure could often turn out to be visually challenging and difficult, as observed in the technical communication literature, including psychological studies in mental imagery and mental rotation.

Visual information becomes necessary for any physical action when it is related to learning a motor skill by observing it. Visual information is important for experiencing how a physical task needs to be completed. Illustrations are often important for novice learners at an early stage of learning when it is hard to understand external physical movements, action sequences and patterns of movement, one that someone has not yet experienced directly and repeatedly in the actual physical world. Technical illustrations when designed properly might help comprehend the exact style of movement, pressure points, actions and reactions, etc. Figure 1 show the major questions raised in the technical communication literature that is related to the comprehension of depth perceptions in illustrations.

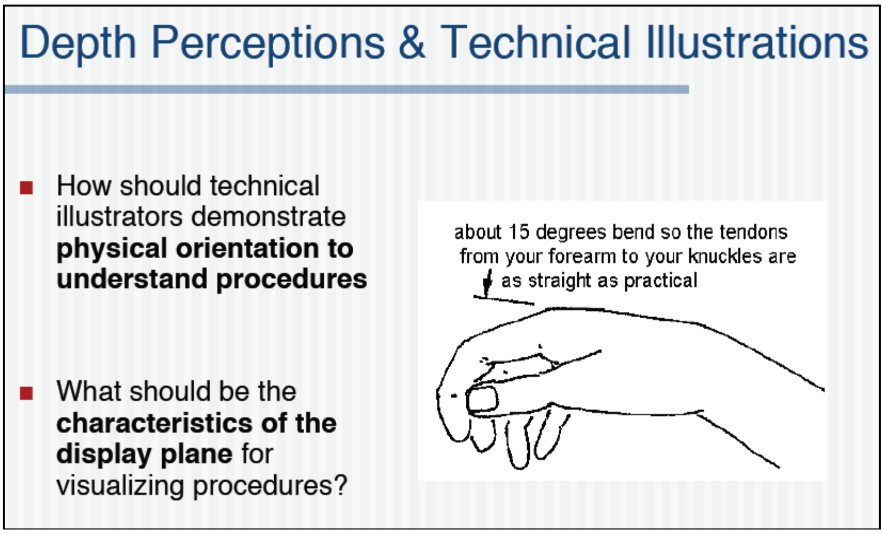

Figure 1. Depth Perceptions and Technical Illustrations

Mental imagery is an experience and an important aspect of our general understanding of how different objects functions in space without direct visualization. In a complex spatial world, mental imagery can present some complex cases of comprehension involving mental rotation. Mental rotation is the ability to rotate two-dimensional and three-dimensional objects in space, but as an internal representation of the mind. It is basically about how the brain moves objects in the physical space in a manner that helps with positional understanding (including structural and functional) in space. Research in psychology [Pylyshyn (1973); Shepard & Metzler (1971)] has provided significant literature demonstrating how people develop and customize mental models and perform mental rotation towards performing procedural actions in space. Their studies (Shepard & Metzler, 1971) have dealt with how mirror images are understood through mental rotation, and a continuous process of mental imagery creation in the reader's mind. However, there could be a gap between what technical illustrators expect users to see, and how users interpret the action. This is where technical illustrations can actually help develop guidelines in a way that might help users perform mental rotations in a predefined or expected sequence.

Technical illustration is the use of drawing, sketch, paintings or photographs to visually communicate information of a technical nature. Illustrations should demonstrate visual images that are accurate in terms of dimensions and proportions, and should provide enough visual cues for the readers to understand exactly how any physical task is to be completed in a given 2-d space. Therefore showing body positions in an illustration could often lead to exact information and help you make a mental image of the physical action. Further, depth perception is the visual ability to perceive the world in three dimensions and the distance between and within objects. For example, people are better at judging distances directly across the display plane (discussed in later sections). Figure 2 sums up the significantly broad issues for technical writers and illustrators who would prefer to design optimal viewpoints for complex procedural actions.

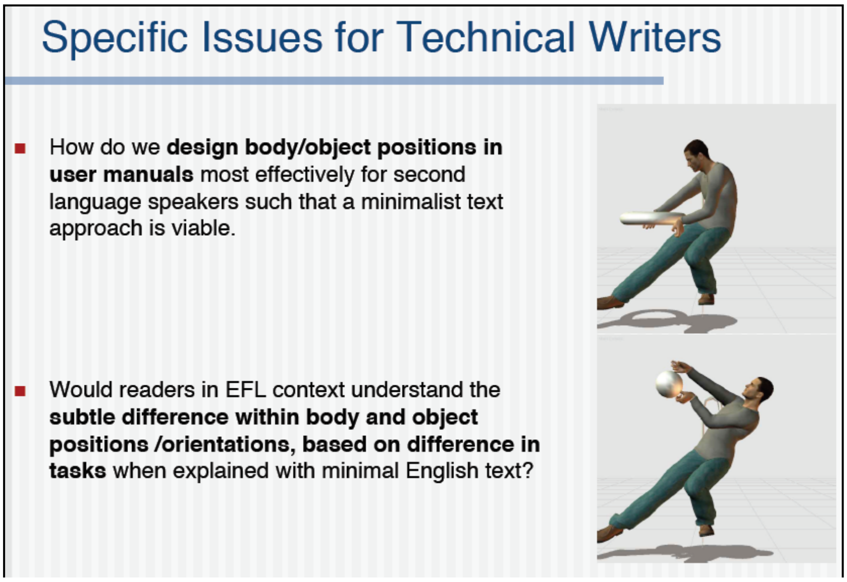

Figure 2. Specific Issues for Technical Writers

The specific research questions that are relevant in this context include the following:

- For a two-dimensional illustration being shown for a task completed in a three-dimensional space, would the readers prefer an object-centered view or a performer-centered view?
- For a two-dimensional illustration being shown for a task completed in a three-dimensional space, would the readers prefer objects being shown with maximum viewpoints across the display plane or into the display plane?
- Should the primary object related to the task be shown below the camera position or at directly horizontal to the camera position?
- Is there any significant difference in the efficiency with which tasks are understood, based on type of task, height at which the task takes place with relation to the human body, and visual angles / perspectives, or some combination of all of the these factors?

This paper is aimed at highlighting these important questions in object visualization with reference to relevant literature that could help us understand the underlying concepts.

Literature Review

Mental imagery is a unique phenomenon in cognitive psychology and is considered an inner experience that plays an important role for memory and thinking. Mental imagery has always been a central character in the research related to classical and modern philosophy. An important challenge and the central focus for this discussion are centered on how the human mind processes mental images.
Figure 3 shows a basic starting point for humans in this process of mental imagery formation. Figure 3 shows an anatomical image plane with Axial, Coronal and Sagittal image slices. If mentally, an image could be perceived with this knowledge of image slices, perception of images probably would get relatively easier.

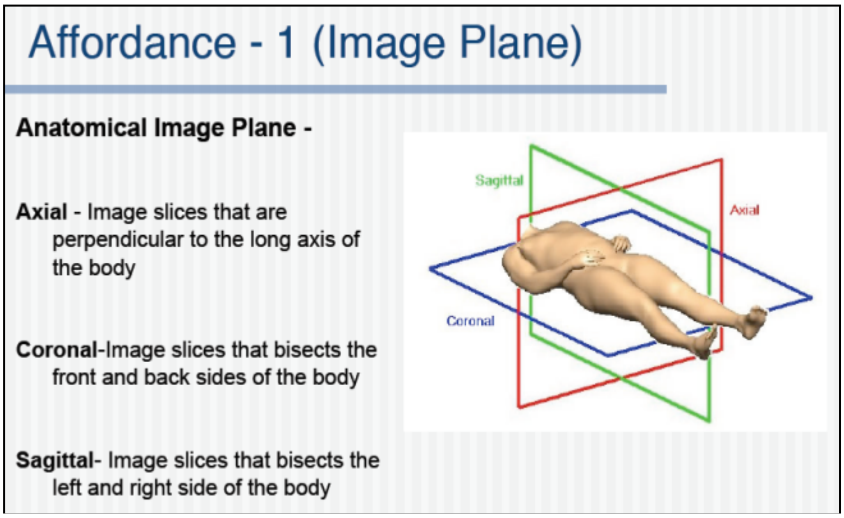

Figure 3. Anatomical Image Plane

Literature on mental rotation suggests mental rotation as the brain's ability and way of moving objects in order to understand what they are and where they belong [Johnson (1990); Jones & Anuza (1982); Hertzog & Rypma (1991)]. Mental rotation refers to how the mind recognizes objects and its positions in space. Researchers call these objects stimuli. A stimulus then would be any object or image seen in the person's environment that has been altered in some way. Mental rotation then takes place for the person to figure out what the altered object is. As mentioned earlier, an anatomical image plane could be the first affordance and stimuli when dissecting an image mentally. Affordance # 2, as would be discussed in the later sections could be showing the optimal viewpoints for an object, which is again related to the understanding and perceptions about the anatomical image plane.

Figure 4 provides an example of optimal perspective for an object. In the picture, a bicycle is shown from a 1/3rd front or side (canonical) viewpoint, and a bottom camera angle shown. The bottom camera angle shows certain viewpoints that are not available from the side or top views. The bottom camera angle is not the ideal canonical view used for illustrations.

A. Bicycle **B. Car canonical viewpoints**

Figure 4. Canonical Viewpoints

Why is it that different people understand different physical procedures in a 2-D environment with differing ability? Besides issues related to design efficiency, the answer probably lies in differing learning processes which emphasize visual, auditory, and kinesthetic systems of experience and preferences in learning styles (Gardner, 1983).

One possible response could be thought of in terms of an individual's ability for mental rotation towards comprehending any physical action. But the ability for mental rotation is also dependent on what people see and cannot see in the presented scene. Figure 5 demonstrates the inherent complexities embedded in visualizing a physical procedure.

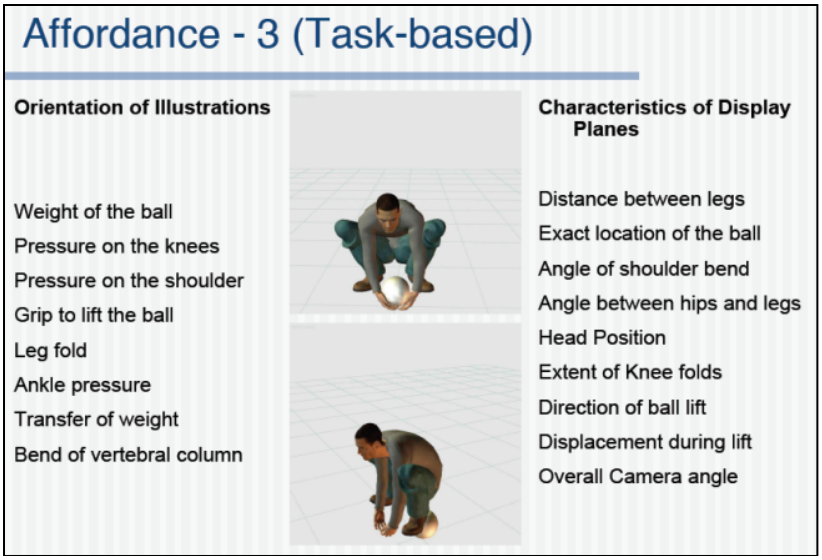

Figure 5. Orientation of Illustrations and Characteristics of Display Planes

The next section helps us to see the difference between orientation of illustrations and characteristics of display plane. The orientation of illustrations in Figure 5 helps us to realize the physical aspects of the task completed, and the challenge associated with its optimal demonstration. The characteristics of the display plane help us see how a body position could be drawn, sketched or photographed in a way so that the physical aspects of the body position are better visualized and comprehended.

Display Plane Dynamics

From a design perspective, people will perform differently with objects or its angles when shown into versus across the display plane (Krull et al., 2003). For objects into the display plane, there will be a question of how well readers can judge the distance between angles and object areas. This is because bodies or objects on the line of sight will obscure vision, and thus result in lack of judgment related to depth cues. On the contrary, objects shown across the display plane show the maximum number of objects and visual angles across the line of sight making it easier to judge objects, and the need for judging depth cues are reduced. However, what needs to be shown depends on the task and the priority. Figure 6 demonstrates the inherent complexities when visualizing a three-dimensional physical task in a two-dimensional plane.

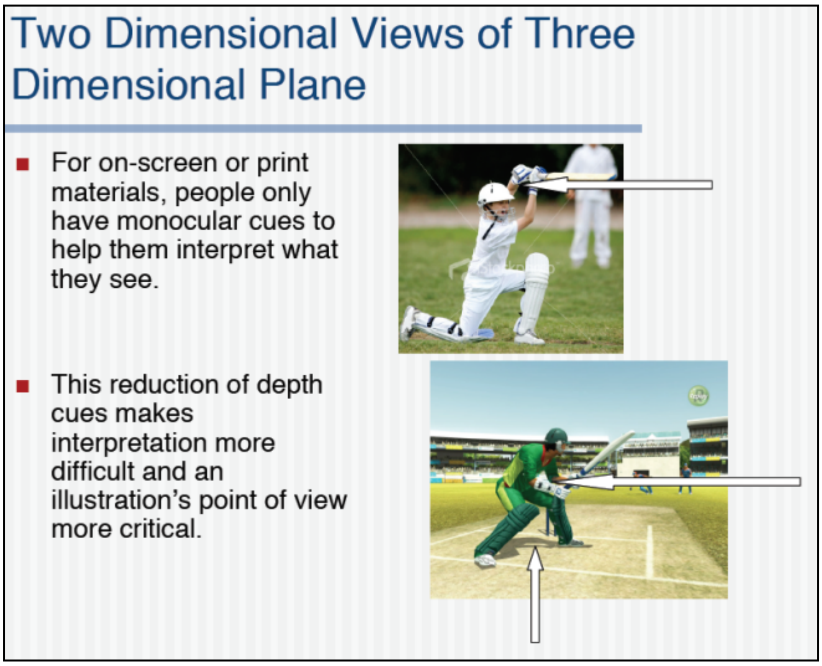

Figure 6. Two Dimensional Views of Three Dimensional Planes

What does this literature mean for a technical communicator and an illustrator who wants to draw objects for explaining a physical procedure in a 3-d print or online environment?

The first question that could be explored in this context is to ask how technical illustrators should demonstrate physical orientation to explain procedures. Another important question for technical communicators would be to understand the characteristics of the display plane for visualizing procedures.

Object and Body-Centered Perspective

Figure 7 shows that objects or a performance could be seen from a spectator's point of view (object-centered) or from a performer's point of view (body-centered). Depending on what the viewer intends to do or see, one perspective might be better than the other and preferred accordingly.

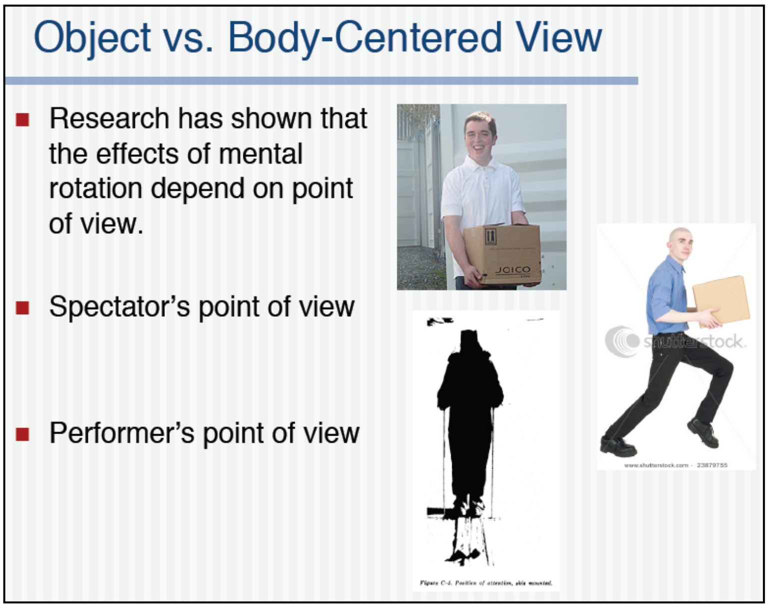

Figure 7. Object vs. Body-Centered View

From a readers' perspective, imagining someone doing a physical action has more positive influence on physical task completion, when compared to no mental practice (Verbunt et al., 2008). This research by Verbunt et al., (2008) is based on "movement imagery", targeting the cognitive processes associated with enhanced motor performance and specific skilled movements in healthy persons. Thus, a process of live mental animation could lead to better comprehension of the task. The important question about mental practice is related to whether the mental practice should be based on the spectator's point of view or the performer's point of view. There is probably no single answer to that question. It depends on the task complexity.

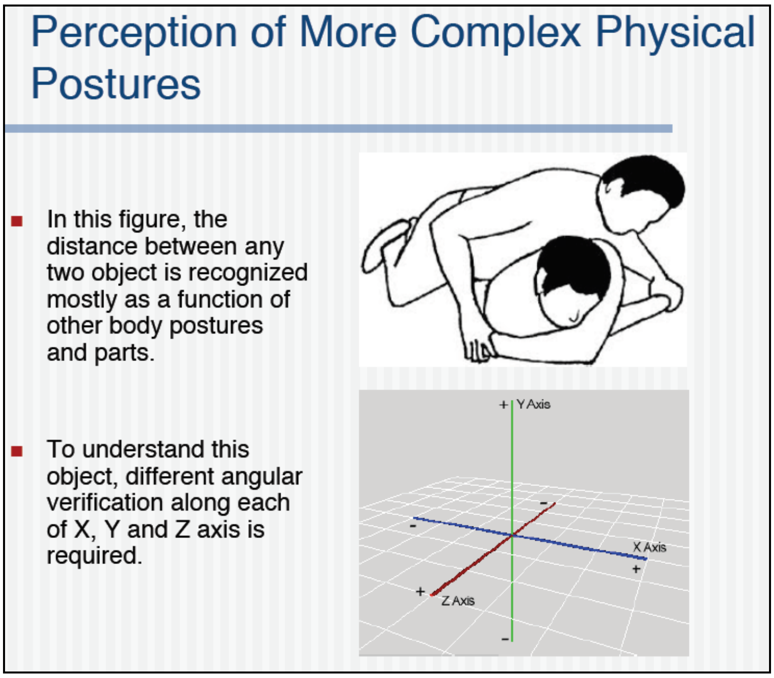

Figure 8. Perception of Complex Physical Tasks

Figure 8 shows that comprehending a physical task become difficult when angles and body parts of humans or objects are intricately embedded as a single physical entity in a display plane. This leads to more object parts being obscured from the line of sight.

There is extensive research done by Krull with the suggestion that graphics for physical tasks need to take into account the needs of users who will carry out actions in a physical environment. Research suggests that graphics need to show tasks from the users' viewpoint, and need to make clear how tools are to be used and the direction in which actions are to be exerted. An illustration with an object-centered point of view positions objects across a display plane (Krull, 1994). This viewpoint, which could also be called a spectator's view, allows objects to be placed so as to direct viewers' attention without obscuring important parts of objects (Krull et al., 2003).

Canonical Viewpoints

Psychological research has concurred that canonical views showing two-dimensional representations of physical actions that are held in a three dimensional world are best represented when illustrations are shown with objects in a three-quarter view from slightly below the camera position. Figure 9 shows research favoring canonical viewpoints in technical illustrations [Heiser & Tversky (2002); Szlichcinski (1980)].

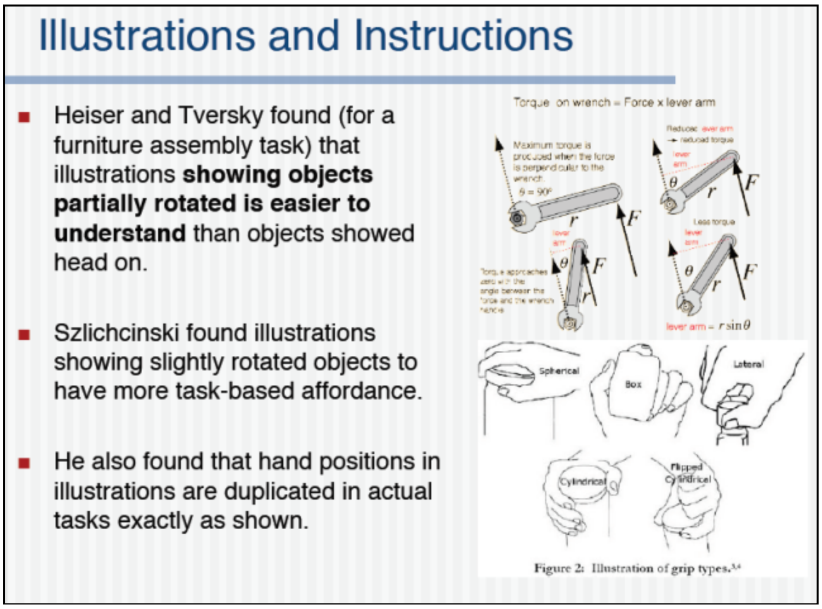

Figure 9. Canonical Viewpoints – Partially Rotated Objects

Although canonical views (slightly rotated viewpoint to show maximum angles) are always preferred, when it comes to replicating a task, the choice between a spectator's viewpoint (seeing the action as an observer and not as a doer) and object-centered viewpoint (seeing the action as a doer and not as an observer) is rather obscure and more context-driven. However, if the focus is simply to adapt an object-centered perspective, the visual could be shown from the back without much thought going into how the task should be completed. This is important to understand because there are individual differences in the way people prioritize objects in space vis-a-vis the orientation of their bodies in space and with different interpretations of visual information and with different performance levels on the task [Milner & Goodale (1995); Zacks et al., (2003)].

Discussions and Conclusion

Research in this specific application context clearly negates the adopted null hypotheses that canonical views showing multiple viewpoints and maximum angles of visibility have a distinct advantage when compared to full front or back views where the viewpoints are expected to be obscured from direct vision. A related research project on matching waist height images with overhead images for the same body task-angle combination, clearly demonstrated that side, 1/3rd back, 1/3rd side views did not have any distinct and statistically significant advantage when compared to other frontal or back views. For different physical tasks shown in a 2D plane, it would be interesting to see the accuracy with which readers are able to judge positions which are manipulated based on three different factors; reportedly body height, rotation angles, and actions. These three variations when happening at once, present multiple confounding variables that should be considered towards interpreting the results. Research so far, on the various aspects of illustrations visualization has not been overwhelmingly significant indicating specific preferences. Future research on the topic is aimed at designing various complex tasks, and pictures tested from multiple viewpoints to understand any trend or preference that facilitates the process of mental animation and imagery.

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