

Cognitive System Analysis of a 3D Naturalistic Workspace System

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Abstract

This paper focuses on analyzing a 3D modeling design team, utilizing naturalistic interface design within a VR environment. This paper recognizes a 3D modeling team consisting of a modeler, texturing, lighting, and composition. Natural interface design is defined as conducting interactions with an interface through multimodal interaction methods involving gesture motions and voice recognition. A cognitive performance evaluation is performed for analyzing critical human and technological functions, values, and purposes. A team work analysis is also conducted to determine where work domains exist and overlap, which provide a better understanding of the team's priorities and purposes. The paper serves as the baseline for implementing this concept into a system engineering structure with a cognitive perspective.

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This paper analyzes the cognitive performance and team work domain analysis of a 3D modeling team specifically made up of modeling, texturing lighting, and composition team members utilizing naturalistic virtual reality (VR) methods for model creation. This analysis is the initial step in capturing cognitive factors that match work domain requirements, ultimately intended for system engineering inclusion.

Traditional 3D Team Environment

In typical large-scale and complex team environments, there is a combination of modeling, texturing, lighting, and composition teams. Modeling is responsible for the geometric creation and “sculpting” of shapes within a virtual space. Texturing involves painting or surfacing the shapes and objects created by the modeling group. Lighting is in charge of applying the dramatic or precisely calculated lighting to an environment and all objects to achieve the exact rendering effects needed. The compositing team is in charge of stitching the whole scene together to ensure it renders seamlessly in the final scene (Houston, 2019). No two teams are the same; therefore, these major team components can be partitioned differently depending on the project goal and the organization’s capabilities. For example, if an animation were part of project deliverables, there would undoubtedly be an animation team involved and a team dedicated to managing sound. Additionally, there are leadership roles such as technical directors, or computer graphic supervisors and directors (Houston, 2019). Due to the scope of this analysis, only the four components mentioned above will be covered. Regardless of the team, all stakeholders, in some way, shape or form should have proficiency in dealing with factors relating to art, technology, and management.

Natural Interface Design

In this paper, natural interface design refers to commands and interactions with an interface through multimodal interaction methods involving gesture motions and voice recognition. Natural interfaces show promising signs for decreasing working memory and easier familiarization with interaction commands. Touch-screen technologies such as tablets utilize natural interface design for interaction in the form of swiping and pinching. Physical gesturing uses real-life movements to engage with the virtual environment, such as picking up, rotating, or moving objects. Iconic gestures represent referent items semantically and are, for the most part,

also embedded in our hand communication lexicon (Marsh & Watt). The use of voice commands can also alleviate task workloads and allow users to activate different options or actions. A combination of gestures and voice recognition can be incorporated into a virtual environment with additional features such as haptic and motion features to manipulate and navigate through a virtual 3D workspace.

Some obstacles need to be addressed, such as ensuring technical tools meet VR requirements to perform seamless, real-time interactions with large amounts of data. It is also vital that software is accurate in order to avoid any distorted actions being carried out. This is especially true when it comes to speech recognition. Additionally, unrecognizable commands could cause for frustration and added task load.

Using natural communication methods can be beneficial in a 3D modeling scenario by allowing a more natural method of "sculpting" objects with a better perceptual understanding, and collaborative experience than traditional methods (Alkemade, Verbeek, & Lukosch, 2017). For example, a rotating hand gesture can rotate a sphere, or pinching a sphere out can increase an object's size. There are educational and technological obstacles to overcome, but solutions to these challenges are possible. In order for naturalistic workspaces to exist, both human and machine needs must be met. A cognitive system engineering approach can assist in the collaborative experience, making sure technological capabilities match human needs.

Cognitive Performance Evaluation

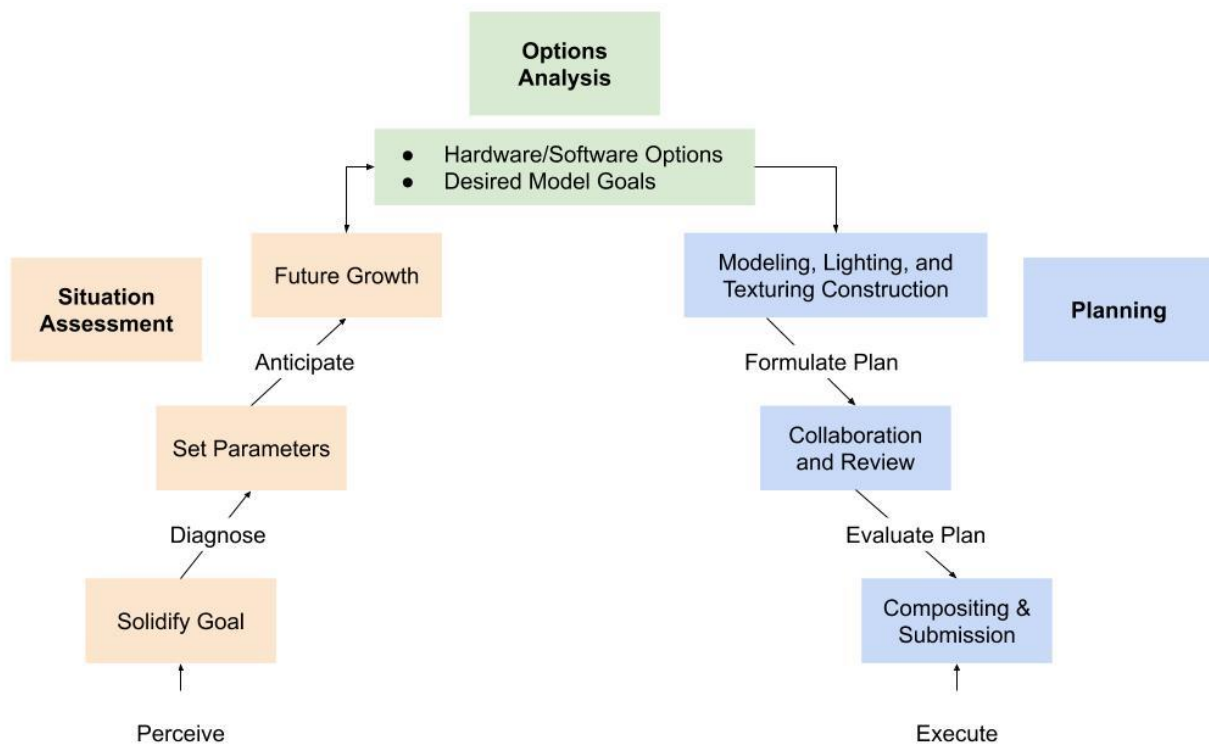
Conducting a cognitive performance review will extract and define critical human and technological functions, values, and purposes (Lintern, 2014). Cognitive performance indicators for this naturalistic 3D workspace are modeling, texture, lighting, and composition of a 3D object; therefore, they will be considered work situations. The primary cognitive processes are situational assessment, options analysis, and planning to carry out the manipulation of a 3D object within a virtual space. The ultimate goal is a decomposition based on the five levels of abstraction (mission purpose, mission values, mission functions, technical functions, physical resources/material layout) (Lintern, 2014). The initial step is to construct a decision ladder.

The creation of a decision ladder will help understand how cognitive states are transformed by cognitive processes, eventually leading to constructing a final approved model, as shown in Diagram 1. Situational assessment is understanding the goals, setting model parameters, and the anticipation of growth (Lintern, 2014). Within the options analysis, technological requirements dealing with hardware and software options are considered and

what the final model should depict. Factors such as immersive or non-immersive, haptic gloves, and virtual reality hardware should be considered and weighed against the project's overall goal. The planning portion of the decision ladder is where most, if not all, natural interactions occur in a 3D workspace. The implementation of modeling, lighting, texturing, and composition is reviewed and collaborated until a final approved 3D model is implemented.

Diagram 1

3D Modeling Decision Ladder



Next, a decomposition table is constructed, as shown in Table 1, extracting mission purpose, mission values, mission functions, technical functions, and physical resources of the project (Lintern, 2014). The strategic mission purpose of the project is to construct 3D objects in a naturalistic manner. The value in doing this is due to a decrease in task load, time, and ultimately cost. Mission operations are modeling, texturing, lighting, and composition of a 3D model. Technologies needed to carry these operations out are a VR system with gesture, voice, and audio recognition. Also, software that can accommodate the VR system and support collaboration within a virtual environment is essential.

Table 1*3D Model Process Abstraction Decomposition Table*

	Abstraction	Observables
Mission Purpose	Naturalistic construction of 3D model	Strategic Reviews
Mission Values	Decrease the task load. Improve process time.	Command Reviews
Mission Functions	Model, Texture, Lighting, and Composition	Operational Assessments Human Resource Assessment
Technical Functions	Virtual reality, Gesture recognition, speech and audio recognition, 3D collaboration software	Technical measurements Modeling
Physical Resources/ Material Layout	VR System (Oculus, Samsung, etc.) Haptic Gloves (Manus, HaptX, etc.) Modelo Collaboration Software (Modelo, Unreal Engine, etc.) VR Modeling Software (Substance Painter)	Technical measurements Inventories Perceptual Inspection

Note. An abstraction of mission purpose, values, and functions, in addition to technical functions and physical resources for a 3D modeling workspace.

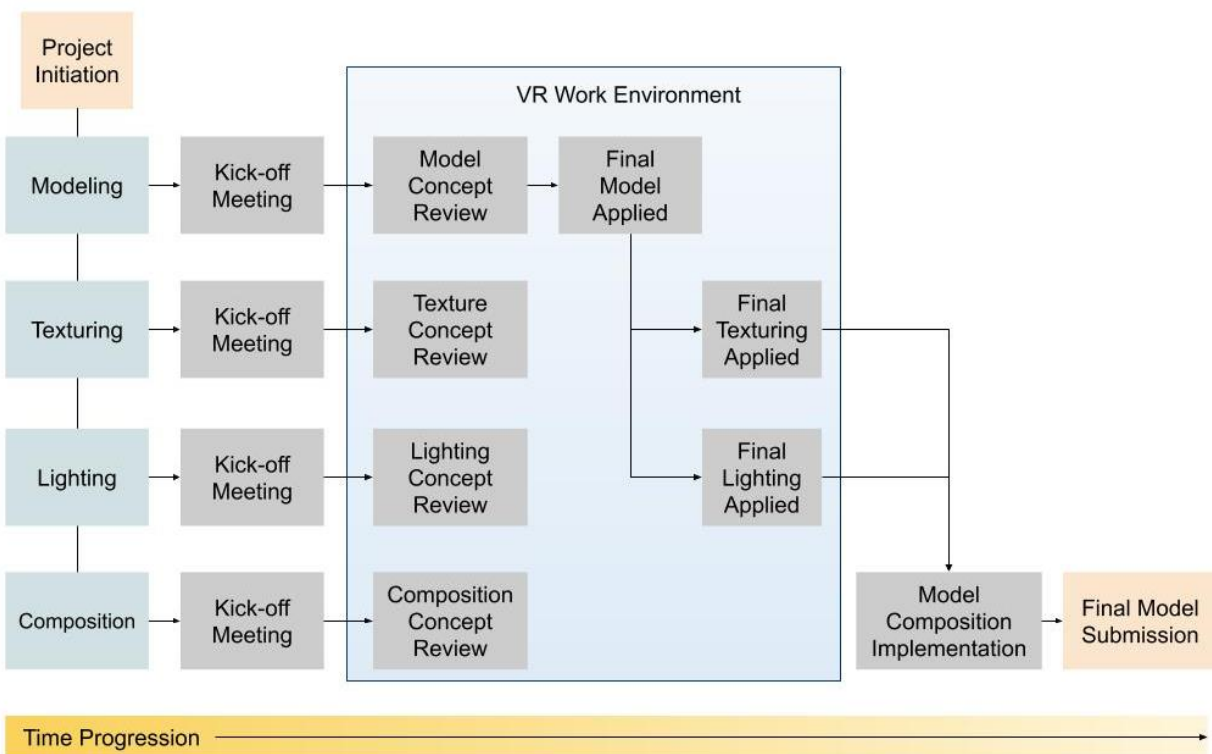
The ability to use cognitive performance indicators to assist in extracting critical cognitive and technical needs provides an opportunity to implement a successful 3D naturalistic modeling project. With critical components decomposed, more-detailed tasks can be further decomposed to provide work domain processes and task requirements.

Team Work Domain Analysis

Setting up a team-centered work domain analysis (TWDA) process will provide design requirements and task distribution information for stakeholders involved in the 3D construction process. (Ashoori and Burns, 2013). TWDA team analysis aims to determine where work domains exist and overlap to understand the team's priorities and purposes. The initial step in the process is to create a trajectory of a 3D modeling project displayed through the various teams as it progresses through time, as shown in Diagram 2—beginning with the initial kick-off meeting set within a traditional workspace with consideration to non-VR outside stakeholders' involvement. Next, the modeling concept review is held within the VR environment, discussing topics such as the scope of the project, model conceptualization, and brainstorming. Once model details are agreed upon, the final model's creation can also be done within VR. As portions of modeling are finalized, proceeding texturing and lighting can be applied to those portions in order to save time. Once all modeling elements are finalized and applied, the final model is delivered to the composition team for stitching the final model into the all-encompassing scene.

Diagram 2

3D Modeling Trajectory

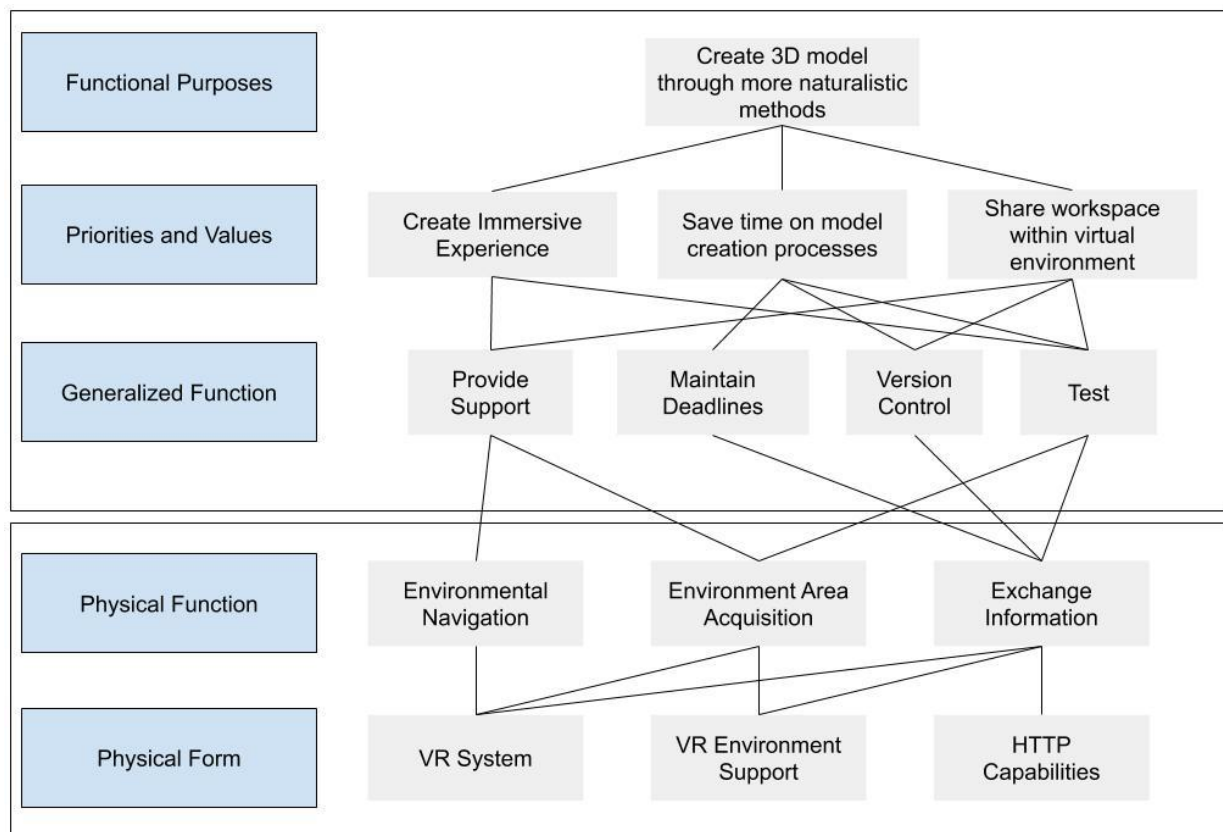


Note. A trajectory displaying the 3D modeling process as it progresses through time, with an indicator illustrating where the VR environment is integrated.

The next step in the process is to create an abstraction hierarchy (AH) to understand work domain restrictions or limitations better, as shown in Diagram 3 (Vicente, 2003). An understanding of where work domains are shared and by which team members is done by examining five components: functional purpose, priorities and value, generalized functions, physical function, and physical form (Ashoori and Burns, 2013).

Diagram 3

3D Modeling Abstract Hierarchy



Note. Abstraction hierarchy of 3D modeling team process using naturalistic methods within a VR environment.

With the abstraction of functions and physical needs established, the constraints and boundaries involved within the work domain can be formulated. Constraint and boundary objects can involve both hardware and software, displaying where and how information is passed between the different teams (Star and Griesemer, 1989). The VR system consists of both hardware and software boundaries, and the installed software presents its own set of limitations along with the computer processing power of device hardware. Environmental support is constrained by the physical boundaries of the area where the human agent will be maneuvering. HTTP capabilities are constrained by the network, internet, and physical line installation capabilities.

Conclusion and Recommendations

This analysis covers the cognitive performance evaluation and team work domain analysis for a 3D team environment. Further analysis can look into more specific functions with the generalized functions outlined in this analysis serving as the foundation. Ideally, a control task analysis would also be beneficial in proceeding studies to uncover the knowledge and skills needed to operate successfully (Bisantz & Burns, 2016). Having the ability to construct 3D models within a VR setting can provide more immersive and improved work experiences, ultimately leading to better material and final products.

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