RNI No. RAJHIN/2007/26996
ISSN 0976-7452 Raaso
Refreed Journal

रासो

अन्तर्विषयी त्रैमासिक शोध पत्रिका

वर्ष-16, अंक-2, मार्च अप्रैल मई 2023

RNI No. RAJHIN/2007/26996
ISSN 0976-7452Raaso
Refreed Journal

रास्सो

इतिहास, संस्कृति, साहित्य एवं दर्शन की त्रैमासिक शोध पत्रिका

वर्ष-16 अंक - 2 मार्च-अप्रैल-मई-2023

☆ सम्पादकीय/सचिव
व्यवस्थापकीय कार्यालय
सृजन संस्थान,
आचमन, वेद विहार,
लोहाखान, अजमेर-06
दूरभाष : 0145-2426610
e-mail : rasoajmjournal@gmail.com

☆ प्रकाशक :
पुष्पा शर्मा
सृजन संस्थान,
द्वारा आचमन पब्लिकेशन्स,
अजमेर

☆ मुद्रक :
मैसर्स आर्य प्रिन्टर्स,
केसरगंज, अजमेर

☆ कम्प्यूटराइज्ड सेटिंग :
श्रीनिवास प्रिन्टोग्राफिक्स
132, पंचवटी कॉलोनी,
अजमेर दूरभाष : 0145-2442701

सहयोग दर

* वार्षिक सदस्यता - 500 रु. (चार अंक) संस्थाओं हेतु - 600 रु. (चार अंक)
कृपया चैक/ड्राफ्ट/मनीऑर्डर श्रीमती पुष्पा शर्मा, प्रकाशक, आचमन पब्लिकेशन्स, अजमेर- 305006 के नाम भेजें।

प्रकाशक-श्रीमती पुष्पा शर्मा, 51/1509, वेद विहार, लोहाखान, अजमेर द्वारा मैसर्स सृजन संस्थान, अजमेर की ओर से प्रकाशित एवं मुद्रक-श्रीमती उषा गर्ग द्वारा मैसर्स आर्य प्रिन्टर्स, केसरगंज, अजमेर से मुद्रित।

Annotating and Sketching on 3D Web Models

Chitrawali Panwar
Asstt. Professor (Department of Science & Technology)
Hukumchand Noble Institute of Science & Technology, Ajmer

Abstract :

The rapid evolution of web technologies has transformed the way three-dimensional (3D) content is created, shared, and interacted with online. Among the most impactful developments is the ability to annotate and sketch directly on 3D web models. These capabilities enable users to add notes, highlights, measurements, drawings, and semantic information on top of complex 3D objects, enhancing communication, collaboration, learning, and decision-making. From architecture and engineering to education, healthcare, digital heritage, and e-commerce, annotating and sketching on 3D web models has become a critical tool for visualization and interaction. This article provides an in-depth exploration of the concepts, technologies, workflows, challenges, and future directions of annotating and sketching on 3D web models, with a focus on web-based platforms and standards.

Introduction :

The World Wide Web has evolved from a platform for static documents into a rich, interactive environment capable of delivering advanced graphics and immersive experiences. With the introduction of WebGL, WebGPU, and powerful JavaScript frameworks, 3D models can now be rendered and manipulated directly within web browsers without the need for plugins. As 3D content becomes increasingly common on the web, users require more than passive viewing capabilities; they need tools to interact, communicate ideas, and collaborate around 3D objects.

Annotating and sketching on 3D web models addresses this need by allowing users to attach information, draw directly on surfaces, and mark regions of interest. Unlike traditional 2D annotations, 3D annotations must consider spatial relationships, depth, viewpoint changes, and interaction complexity. This makes the problem both technically challenging and conceptually rich.

Understanding 3D Web Models :

What Are 3D Web Models?

3D web models are digital representations of objects, environments, or

scenes that can be viewed and interacted with through a web browser. These models may represent anything from simple geometric shapes to highly detailed architectural structures or anatomical models. Common file formats include glTF, OBJ, FBX, and STL, with glTF emerging as a preferred standard due to its efficiency and web-friendly design.

Rendering 3D Content on the Web :

Modern browsers support real-time 3D rendering through technologies such as:

* WebGL: A JavaScript API for rendering interactive 2D and 3D graphics.

* WebGPU: A next-generation graphics and compute API offering improved performance and flexibility.

* 3D Libraries and Frameworks: Tools such as Three.js, Babylon.js, and PlayCanvas simplify 3D development by providing higher-level abstractions.

These technologies form the foundation upon which annotation and sketching systems are built.

Concept of Annotation in 3D Environments

Definition of 3D Annotation

3D annotation refers to the process of attaching information to specific points, surfaces, or regions of a 3D model. An annotation may include text, symbols, images, measurements, links, or metadata. Unlike 2D annotations, 3D annotations are spatially anchored and must remain meaningful as the user rotates, zooms, or navigates the model.

Types of 3D Annotations : Common types of annotations include:

* Point-based annotations: Notes attached to a specific point in 3D space.

* Surface-based annotations: Highlights or labels applied to faces or regions.

* Volume-based annotations: Annotations associated with a 3D region or bounding box.

* Semantic annotations: Metadata describing the function, category, or meaning of a model component.

Importance of Context and Viewpoint

In 3D environments, the visibility and readability of annotations depend heavily on camera position and orientation. Effective systems dynamically adjust annotation placement, scale, and orientation to maintain clarity without cluttering the view.

Sketching on 3D Web Models

What Is 3D Sketching?

Sketching on 3D web models involves drawing freehand lines, shapes, or

markings directly onto or around a 3D object. These sketches can be used to illustrate ideas, propose modifications, emphasize features, or explain concepts.

Difference Between 2D and 3D Sketching

While 2D sketching occurs on a flat plane, 3D sketching must account for depth, perspective, and surface curvature. Sketches may be:

* Screen-space sketches, which are drawn relative to the camera view.

* World-space sketches, which are projected onto the model's surface or into 3D space.

Each approach has different implications for accuracy, usability, and interpretation.

Use of Stylus and Touch Interfaces

With the rise of touch-enabled devices and stylus input, sketching on 3D models has become more intuitive. Web-based tools increasingly support pressure sensitivity, gesture-based controls, and multi-touch interactions.

Technical Foundations of Annotation and Sketching :-

Coordinate Systems and Spatial Anchoring

To attach annotations reliably, systems must convert user input from screen coordinates into 3D world coordinates. This involves techniques such as ray casting, hit testing, and surface intersection detection.

Data Structures and Storage

Annotations and sketches are typically stored as structured data, including:

* Position and orientation in 3D space

* Visual properties (color, size, style)

* Associated metadata and user information

Web applications often use JSON-based formats and cloud databases to enable persistence and sharing.

Performance Considerations

Rendering large numbers of annotations and sketches can impact performance. Efficient batching, level-of-detail management, and GPU acceleration are essential for maintaining smooth interaction.

User Interface and Interaction Design

Design Principles : Effective annotation and sketching tools must balance functionality with simplicity. Key design principles include:

* Clarity and readability

* Minimal visual clutter

* Consistent interaction patterns
* Immediate feedback to user actions

¢ Interaction Techniques : Common interaction techniques include:

Click or tap to place annotations

* Drag to reposition or resize
* Drawing gestures for sketching
* Context menus for editing and deletion

Accessibility Considerations : Web-based 3D tools should consider accessibility by supporting keyboard navigation, screen readers (where possible), and adjustable visual settings.

Applications Across Domains :-

Architecture, Engineering, and Construction (AEC)

In the AEC industry, annotating and sketching on 3D models supports design reviews, clash detection, and collaborative decision-making. Stakeholders can mark issues directly on building models, reducing misunderstandings and errors.

Education and E-Learning

3D annotations enhance learning by allowing instructors to label parts of models, explain processes, and guide student exploration. Sketching helps visualize abstract concepts in subjects such as physics, biology, and engineering.

Healthcare and Medical Visualization

Medical professionals use annotated 3D models for surgical planning, patient education, and training. Sketching enables highlighting regions of interest and simulating procedures.

Cultural Heritage and Museums

Digital replicas of artifacts and historical sites can be annotated with contextual information, narratives, and expert insights, enriching virtual museum experiences.

Product Design and E-Commerce

Designers and customers can annotate 3D product models to discuss features, suggest improvements, or understand functionality before manufacturing or purchase.

Collaboration and Multi-User Environments :-

Real-Time Collaboration

Web-based platforms increasingly support real-time collaborative

annotation, where multiple users can view and edit annotations simultaneously. This requires synchronization mechanisms and conflict resolution strategies.

Versioning and Change Tracking

Tracking changes to annotations and sketches is essential for accountability and iterative design. Version control systems help manage edits and maintain history.

Challenges and Limitations :-

Usability Challenges : Navigating and annotating complex 3D models can be difficult for non-expert users. Poor interface design may lead to confusion or misinterpretation.

Technical Constraints : Browser performance, device limitations, and network latency can affect the responsiveness and reliability of annotation tools.

Standardization Issues : The lack of universal standards for 3D annotations makes interoperability between platforms challenging. Efforts are ongoing to define common formats and APIs.

Security and Privacy Considerations : Annotations may contain sensitive information, especially in industrial or medical contexts. Secure authentication, authorization, and data encryption are essential to protect user data and intellectual property.

Emerging Trends and Future Directions :-

Integration with AR and VR : Annotating and sketching in augmented and virtual reality environments extends 3D interaction beyond the screen, offering more immersive and natural workflows.

AI-Assisted Annotation : Artificial intelligence can assist users by automatically generating annotations, recognizing objects, and suggesting relevant information.

Web Standards and Interoperability : As web standards evolve, more robust and interoperable solutions for 3D annotation and sketching are expected, enabling seamless exchange of annotated models across platforms.

Conclusion :

Annotating and sketching on 3D web models represents a significant advancement in how people interact with digital 3D content. By enabling users to add meaning, context, and creativity directly to 3D objects, these techniques enhance communication, collaboration, and understanding across a wide range of applications. Despite technical and usability challenges, ongoing advances in web technologies, interaction design, and artificial intelligence are steadily expanding the capabilities and accessibility of 3D annotation and sketching. As

the web continues to evolve into a truly three-dimensional medium, these tools will play an increasingly central role in shaping how we create, share, and interpret digital knowledge.

ꕥꕥꕥ

References

1. *Angel, E., & Shreiner, D. (2019), Interactive Computer Graphics: A Top-Down Approach with WebGL (7th ed.) , Pearson Prakashan.*
2. *Parisi, T. (2012) , WebGL: Up and Running, O'Reilly Media (O'Reilly Prakashan).*
3. *Dirksen, J. (2013) , Learning Three.js: The JavaScript 3D Library for WebGL. , Packt Publishing (Packt Prakashan).*
4. *Dirksen, J. (2018) , Learn Three.js - Third Edition: Programming 3D Animations and Visualizations for the Web , Packt Publishing.*
5. *Cozzi, P., & Ring, L. (2011) , 3D Engine Design for Virtual Globes , A K Peters / CRC Press (Taylor & Francis Prakashan).*
6. *Bowman, D. A., Kruijff, E., LaViola Jr., J. J., & Poupyrev, I. (2004, reprinted 2017), 3D User Interfaces: Theory and Practice. , Addison Wesley / Pearson.*
7. *Burdea, G., & Coiffet, P. (2003, 2nd ed.) , Virtual Reality Technology , Wiley (Wiley India Prakashan - Indian edition available).*
9. *Dix, A., Finlay, J., Abowd, G., & Beale, R. (2004), Human-Computer Interaction (3rd ed.) , Pearson Education.*
10. *Gruber, L., et al. (2021) , Augmented Reality: Principles and Practice (2nd ed.) , Addison Wesley (Pearson).*
11. *Craig, A. B. (2013, 2nd ed.) , Understanding Augmented Reality: Concepts and Applications , Morgan Kaufmann (Elsevier Prakashan).*
12. *Haines, E., & Akenine Möller, T. (2018) , Ray Tracing Gems: High Quality and Real Time Rendering with DXR and Other APIs , Apress / Springer.*
13. *Lengyel, E. (2012) , Mathematics for 3D Game Programming and Computer Graphics (3rd ed.) , Cengage Learning.*