ChemVisionAR
Final Project Report - Virtual and Augmented Reality

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Abstract

ChemVisionAR is an interactive Augmented Reality (AR) application that visualizes atomic structures and simulates chemical reactions. Using Unity with AR Foundation and AR Core, it enables users to scan QR codes for elements like Hydrogen, Carbon, and Oxygen to generate 3D atomic models with electron orbits and atomic details. The system simulates reactions, such as CO_2 formation, by detecting atom combinations and providing visual transitions, audio feedback, and contextual world-space UI. ChemVisionAR offers an engaging, immersive tool to simplify learning of atomic structures and chemical processes, showcasing AR's potential in interactive science education.

1. Introduction

Traditional methods struggle to engage students in understanding atomic structures and chemical reactions due to their abstract nature. Static images and physical models lack interactivity, making 3D visualization and molecule formation difficult.

ChemVisionAR addresses this challenge using Augmented Reality (AR) with AR Foundation (Unity) and AR Core (Google). AR improves learning, motivation, and collaboration [1, 2], yet remains underutilized for complex visualizations.

By visualizing 3D atomic models via QR codes, displaying atomic details through interactive UI, and simulating reactions like CO_2 formation with audio feedback, ChemVisionAR transforms abstract concepts into engaging, accessible learning experiences for Android devices.

2. Results and Demonstration

The **ChemVisionAR** system demonstrates atomic visualization, interaction, and chemical reaction simulation using Augmented Reality (AR). Key features include:

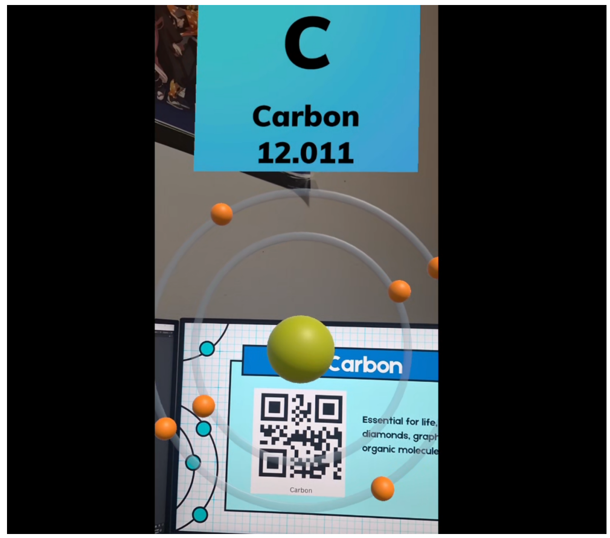

Figure 1. Visualization of Carbon atom.

- **Atomic Visualization:** Scanning QR codes for elements like Hydrogen, Carbon, and Oxygen generates interactive 3D atomic models. Electron orbits are simulated using C# scripts, and world-space UI displays atomic details such as number, weight, and structure (Fig. 1).

- **Reaction Simulation:** The system validates reactions such as CO_2 formation. When Carbon and Oxygen atoms are detected, the "React" button replaces individual atoms with a CO_2 molecule and triggers audio feedback explaining its significance (Fig. 2).

- **User Interaction and Feedback:** The intuitive interface includes a React button for molecule formation and audio feedback to enhance engagement. ChemVisionAR supports multi-level representations—macroscopic (observable reactions) and microscopic (atomic structures)—to deepen conceptual understanding [5] (Fig. 3).

Project Presentation and Demo: Access Here

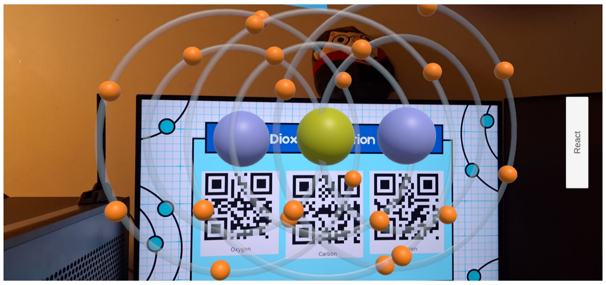

Figure 2. Formation of CO_2 molecule.

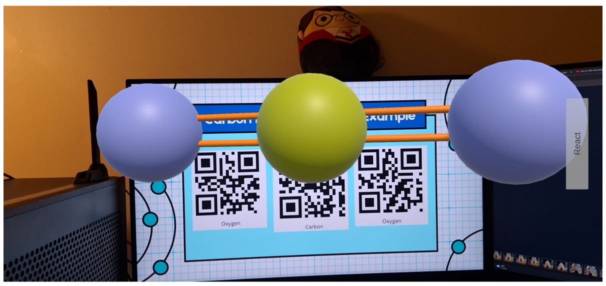

Figure 3. Molecule formation with audio feedback.

3. Implementation

The **ChemVisionAR** system integrates AR technology for visualizing atomic structures and simulating chemical reactions. Key components include:

- **Technology Stack: Unity Engine** for 3D modeling and UI, **AR Foundation & AR Core** for tracking and QR detection, and **C#** for scripting logic.
- **QR Code Detection:** Using ARTrackedImageManager, QR codes spawn 3D atoms with rotating electron orbits (C# scripts) and world-space UI for atomic details (number, weight, structure), supporting effective molecular visualization [3].
- **Reaction Logic:** The Reaction Manager detects combinations (e.g., 1 Carbon + 2 Oxygen), activates the React Button, replaces atoms with molecules (e.g., CO_2), and plays audio feedback. [3].
- **User Interaction:** Screen-space UI for triggering reactions and world-space UI for inline atomic details enhance real-time learning.
- **Audio Feedback and 3D Models::** Unity's AudioSource provides auditory explanations, enhancing engagement and multi-sensory understanding. Custom atom and molecule models with animated electron orbits (C#) ensure accuracy and flexibility.
- **System Workflow:**
  1. QR codes instantiate 3D atoms.
  2. Reaction Manager validates molecule conditions.
  3. React Button replaces atoms and triggers audio feedback.
- **Testing:** Tested on ARCore-compatible devices; tracking issues were mitigated through optimization for smooth performance [3].

4. Discussion

The **ChemVisionAR** system enhances understanding of atomic structures and chemical reactions through interactive AR features. Key observations include:

- **Improved Understanding:** 3D visualization simplifies abstract chemistry concepts.
- **Increased Engagement:** Interactive elements and audio feedback boost motivation.
- **Collaborative Potential:** AR fosters teamwork and spatial intuition in learning environments [4].
- **Accessibility:** Smartphone compatibility ensures affordability and easy adoption.

Despite its benefits, limitations include:

- **Device Dependency:** Requires ARCore-compatible devices.
- **Content Scope:** Currently limited to a small set of atoms and reactions.

Future Work:

- Expand chemical content and reaction simulations.
- Improve tracking accuracy for smoother performance.
- Integrate collaborative features and guided experiments for multi-student learning [4].

Conclusion: ChemVisionAR demonstrates AR's potential to transform chemistry education, making abstract concepts interactive and engaging while offering room for further enhancements in content and collaboration.

References

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