A Conformal Geometric Algebra framework for Mixed Reality and mobile display

Margarita Papaefthymiou[a] , **George Papagiannakis**[a], **Andreas Aristidou**[b] and **Marinos Ioannides**[b]

[a] Foundation for Research and Technology – Hellas and
University of Crete, Heraklion, Greece
mpapae02@ics.forth.gr [presenter], papagian@ics.forth.gr [corresponding]

[b] Department of Electrical Engineering, Computer Engineering and Informatics
Cyprus University of Technology, Limassol, Cyprus
a.aristidou@ieee.org, marinos.ioannides@cut.ac.cy

Over the last few years, recent advances in user interface and mobile computing, introduce the ability to create new experiences that enhance the way we acquire, interact and display information within the world that surrounds us with virtual characters [1], [2]. Virtual Reality (VR) is a 3D computer simulated environment that gives the user the experience of being physically present in real or computer-generated worlds; on the other hand, Augmented Reality (AR) is a live direct or indirect view of a physical environment whose elements are augmented (or supplemented) by computer-generated sensory inputs. Both technologies use interactive devices to achieve the optimum adaptation of the user in the immersive world achieving enhanced presence [1], harnessing latest advances in computer vision, glasses or head-mounted-displays featuring embedded mobile devices. A common issue in all of them is interpolation errors while using different linear and quaternion algebraic methods when a) tracking the user's position and orientation (translation and rotation) using computer vision b) tracking using mobile sensors c) using gesture input methods to allow the user to interactively edit the augmented scene (translation, rotation and scale) d) animation blending of the virtual characters that augmented the mixed reality scenes (translation and rotation).

In this proposed talk, we aim to enhance the conformal model of Geometric Algebra (CGA) [3], [4] as the mathematical background for camera, display and character animation control [2] in immersive and virtual technology, such as head-mounted displays (e.g. Google Cardboard™) or modern smartphones; a framework that offers a smooth and stable calibration/control can be used in real-time mobile mixed reality systems that featured realistic, animated virtual human actors who augmented real environments. The conformal model of Geometric Algebra is a mathematical framework that provides a convenient mathematical notation for representing orientations and rotations of objects in three dimensions, a compact and geometrically intuitive formulation of algorithms, and an easy and immediate computation of rotors; CGA extends the usefulness of the 3D GA by expanding the class of rotors to include translations, dilations and inversions. Rotors are simpler to manipulate than Euler angles; they are more numerically stable and more efficient than rotation matrices, avoiding the problem of gimbal lock. The results of this work allow us to a) unify and improve the performance of previously separated linear and quaternion algebra camera transformations b) fully replace quaternions for rotation interpolation with faster CGA rotors, c) blend rotations and translations between character animations using CGA, under a single geometric algebraic framework using CGA for Mixed Reality applications.

REFERENCES

[1] Egges, A., Papagiannakis, G., and Magnenat-Thalmann, N. (2007). Presence and interaction in mixed reality environments. Visual Computer 23, 5, 317–333.

[2] Papagiannakis, G., Elissavet, G., Trahanias, P., and Tsioumas, M. (2014). A Geometric Algebra Animation Method for Mobile Augmented Reality Simulations in Digital Heritage Sites. In: Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. Springer International Publishing, 258–267.

[3] Hestens, D., Sobczyk, G. (1984). Clifford Algebra to Geometric Calculus: A Unified Language for Mathematics and Physics. Reidel, Dordrecht

[4] Aristidou, A., Lasenby, J. (2011). Inverse Kinematics solutions using Conformal Geometric Algebra, In L. Dorst and J. Lasenby (Eds), Guide to Geometric Algebra in Practice, Springer Verlag.