An Automated Approach for the Translation and Optimization of Military Source Data for Commercial Game Environments

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Introduction

The past five years has seen a significant increase in the use of commercial game technology adopted for the military training and simulation domains. This technology has the capability to produce extremely immersive, highly-detailed 3D environments, though the authoring of the visual content remains a mainly manual process with teams of artists spending several months and thousands of dollars to create very small sections of terrain. This paper presents one approach for the automated conversion, manipulation, optimization, and annotation of military urban terrain data for rendering in commercial game technology. The goal of this pipeline is to reduce the overall effort (in time and resources) required to create highly-immersive, detailed virtual environments for rendering in commercial game systems. We discuss the details of the original military source data, including polygon-counts, levels-of-detail, normal assignments, etc., and how this data is eventually converted for use in a variety of real-time, game-based environments. Our pipeline employs the use of the open-source COLLADA format, which is an open standard digital asset representation for interactive 3D applications. COLLADA defines an XML database schema that enables 3D authoring applications (such as 3dsMax and Maya) to freely exchange digital assets without the loss of information such as object hierarchies and programmable shader effects (Collada, 2007). Once converted to COLLADA, the source data may be exported directly to a rendering environment that supports the interchange format (such as Gamebryo or OLIVE), but often the data requires additional manipulation before final rendering. This automated manipulation process is performed inside of Maya, one of the leading content creation tools used throughout the game industry. After the data has been manipulated and optimized, it may be exported back to COLLADA or to one of the many rendering environments with a Maya exporter available (Unreal, Gamebryo, OGRE, VBS1/2).

Details

In contrast to the often fictitious environments represented by commercial video games, terrain databases used for military simulations typically require accurate correlation with the real-world regions they represent. To achieve this correlation, standard digital terrain source formats such as DTED, ESRI Shape, and GeoTIFF are often used. These formats are capable of storing elevation data, cultural feature data, and geospecific imagery with high resolution, though they currently lack some of the capabilities required by high-fidelity rendering environments such as per-pixel lighting, normal maps, and high dynamic range (HDR) effects. The pipeline presented here takes this collected data and automatically processes it using the Rapid Unified Generation of Urban Databases (RUGUD) framework to create textured terrain meshes, buildings, trees, and other geometry. RUGUD, a currently available GOTS tool, can then export the geometry into correlated SAF and visual terrain database formats, including COLLADA. The COLLADA database is created hierarchically using a terrain master file that externally references the terrain mesh and its features. Referenced feature models, such as buildings and trees, each have their own COLLADA file that allows them to be post-processed independently.

Once the source data has been converted to COLLADA it often requires additional manipulation for efficient and high-quality rendering inside of a game-based environment. Because the original data is often procedurally generated, we are able to algorithmically optimize different parts of a scene. This includes operations like removing duplicate edges between polygons, vertex-welding, normal reassignment, and refactoring the UV layout. After the data has been optimized in Maya, there is the option to embed in it more abstract-level information that can be used by the artificial intelligence (AI) or human user within the game environment. Current modeling and simulation (M&S) environments typically rely on primitive elements of the terrain for an agent's decisions, and often at a very low-level such as used for path-planning and navigation. These elements are nowhere near the level of fidelity required for representing complex and variable agent behavior such as culture. Geometry, collision surfaces, ground type, path nodes and pathing networks are well-suited for basic mobility and physics calculations but fail to accurately convey higher-level information that may be useful to an agent in achieving its goals. Ultimately, it is the patterns, landmark references and cultural influences, not the geometry and their facades, that influence both an agent's low-level actions (movement, gestures) and high-level perceptions and emotions. Our approach is to embed this contextual information (through annotations and affordances) directly in the virtual environment (i.e., terrain) and have the AI use this information in its decision making. Drawing upon other academic fields (psychology, sociology, business/management, healthcare, and security), a broad classification hierarchy of cultural characteristics has been developed that is derived from the types of models presented by researchers like Triandis (1989) and Hofstede (2005). These characteristics are grouped into first and second-order aspects of culture. First-order aspects include the descriptors most people would use to define their cultural identity (race, ethnicity, nationality, politics, religion, economic status, age, gender, etc.). Second-order aspects of culture attempt to characterize more directly how the first-order aspects influence beliefs, attitudes and actions (individuality, egalitarianism, risk acceptance/avoidance, short/long term oriented, task/relationship focused, etc.).

Embedding this type of metadata allows agents to apply context to the objects around them and, as a result, provide a more immersive and realistic simulation experience. USC-ICT has developed an approach and series of tools for “marking up” the terrain with these culturally-derived annotations and affordances, and preserving it in the final export to the game environment. Once the data has been optimized and annotated it is then ready for final export to the rendering environment, which leverages existing export tools created for the game engines.

We believe this pipeline has the potential to significantly reduce the time and effort required to develop terrain data for use in 3D game environments. Additionally, the embedding of contextual metadata supports a much richer representation of the terrain that can be used by the AI or a human user. Future work includes continued optimization of the terrain data and developing a series of techniques and processes for algorithmically manipulating the data to support features of today’s high-fidelity rendering environments (normal mapping, HDR, etc).

References

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Author Biographies

Ryan McAlinden is a Computer Scientist with over six years experience working with and developing commercial game-based applications for the military and research communities. This includes his role as the lead engineer on several ICT projects including the Integrating Architecture project and Densely Populated Urban Environments. His work includes several in-depth evaluations of commercial game technologies and how they are best applied to the military simulation and research domains. He has also worked extensively developing research applications for converting GIS and military terrain data into commercial game standards. He received his B.S. from Rutgers University and M.S. in Computer Science at the University of Southern California.

William Clevenger has a background in applied mathematics and is currently a Research Programmer at USC’s Institute for Creative Technologies. His current work focuses on translating real world geographic data into artist and game-ready formats, and simulating complex, diverse and densely populated urban areas.

John Mann is a Principal Computer Scientist at ARA. For the last ten years he has been involved with the development and integration of physics-based urban modeling tools.

He is the project manager for the Urban and Underground Model Generator (U2MG) project and the Automated Creation of Terrain for Analysis and Visualization (ACTAViz) project. Under both of these programs, ARA is developing rapid urban terrain generation capabilities to support simulations and games used by the Army, Joint and civil sectors. Mr. Mann has a B.S. in Computer Science from the University of Maryland.

Tim Walker is a Senior Computer Scientist at ARA. For the last two years he has developed tools used for automating the generation of simulated urban terrain databases and is currently the technical lead for the Urban and Underground Model Generator (U2MG). Mr. Walker has a B.S. in Computer Science from the University of Central Florida.