Journal of Visual Languages and Computing 20 (2009) 236–251

Contents lists available at ScienceDirect

Journal of Visual Languages and Computing

journal homepage: www.elsevier.com/locate/jvlc

AgentCubes: Incremental 3D end-user development

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ARTICLE INFO

Keywords:
Incremental 3D
Game design
Visual programming
End-user development
IT fluency
Computational thinking

ABSTRACT

3D game development can be an enticing way to attract K-12 students to computer science, but designing and programming 3D games is far from trivial. Students need to achieve a certain level of 3D fluency in modeling, animation, and programming to be able to create compelling 3D content. The combination of innovative end-user development tools and standards-based curriculum that promotes IT fluency by shifting the pedagogical focus from programming to design, can address motivational aspects without sacrificing principled educational goals. The AgentCubes 3D game-authoring environment raises the ceiling of end-user development without raising the threshold. Our formal user study shows that with Incremental 3D, the gradual approach to transition from 2D to 3D authoring, middle school students can build sophisticated 3D games including 3D models, animations, and programming.

1. Introduction: why Incremental 3D?

Kindergarten to 12th grade (K-12) Information Technology (IT) education fails to attract the necessary number of students to Computer Science (CS) especially at the middle school level, when students make critical career decisions by judging their own aptitudes for math and science. Fueled by bad experiences with programming, middle school IT curricula have disintegrated into keyboarding, web browsing, word processing and PowerPoint workshops with little authentic enticement foreshadowing CS careers. This is a very serious problem because, despite the growing need for IT workers, the enrollment in undergraduate degree-granting CS programs in the US dropped by 70% between 2000 and 2005 [1].

The notion of IT fluency is slowly gaining momentum in education as a means to train and evaluate IT skills beyond just using applications. For instance, the National Academy of Sciences' Fluency with Information Technology (FIT) framework [2] postulates a set of skills including meta-skills such as problem solving, creativity, working in groups, algorithmic thinking, and computational thinking [3]. Game design [4] and computational science [5] are gradually establishing themselves as application domains capable of balancing the educational and motivational concerns of IT fluency and attracting not only boys, but students underrepresented in CS such as girls and minorities. In fact, an independent study conducted by the Stanford School of Education using AgentSheets [6–9], our 2D authoring environment, suggested that girls and boys alike are interested in game design [10]. With the right combination of tools, curriculum and teacher training, game design can be employed effectively to teach IT to middle school students in a motivating way.

A fundamental challenge to the notion of fluency is the need to define skills, explore motivational means of promoting skills, and devise ways to assess these skills. Some talk about programming as the new literacy [11]. The focus of our research is to promote the notion of 3D fluency. People live in a 3D world; meanwhile, because of computer gaming, today's computers are highly capable of processing 3D information. Unfortunately, creating

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doi:10.1016/j.jvlc.2009.04.001

computational 3D artifacts and games can be a truly daunting task. Even end users familiar with making 2D games are likely to find the transition to 3D to be difficult. A completely new set of tools is usually necessary to create 3D models that can be animated and programmed. For instance, there is very little skill transfer from 2D paint programs such as Photoshop to a 3D modeling editor such as Maya 3D. This raises the question: Is this discontinuity a conceptual consequence of 2D vs. 3D with potential roots in human cognition, or is it more of an accidental consequence of computational tools that have emerged disjointedly for 2D and 3D applications?

Our goal is to promote 3D fluency through a gradual approach that we call Incremental 3D. We reconceptualize the universe of 2D and 3D tools and skills as a continuum rather than a dichotomy. Most tools support either 2D or 3D authoring. For example, NetLogo [12] and Scratch [13] are 2D authoring environments aimed at K-12; BlueJ [14,15] and GreenFoot [16] are targeted for more advanced students, typically at the undergraduate level, and Macromedia Flash at professional designers. Alice [17], NetLogo 3D, StarLogo TNG [18], DarkBASIC [19], and Macromedia Director are 3D authoring environments with varying degrees of usability for different audiences. Some 2D tools are starting to integrate 3D authoring. However, some of them have a limited degree of integration with the 2D product (e.g. Swift3D is a separate component for Flash) or force the user to drop from a visual language level to a textual language with a 3D application programming interface (API) (e.g. GameMaker [20]). AgentCubes, on the other hand, is a tool that supports 3D authoring through incremental approaches for all components of the 3D authoring process, namely modeling, animation, and programming. A gentle slope [21–23] approach allows end users to develop 3D games by first creating a 2D version of that game and then gradually moving along well-defined stepping-stones towards a 3D version. Our hope is that this incremental process ultimately allows end users to make 3D applications just as easily as 2D applications by transferring existing skills.

This article assesses the idea of Incremental 3D as an approach for end users to create 3D games and acquire IT fluency in the process. The focus of the paper is not the technical implementation but to describe and evaluate the notion of Incremental 3D. A more detailed description of the AgentCubes architecture can be found elsewhere [30]. We first describe the components of Incremental 3D, namely incremental modeling, animation, and programming, in the context of AgentCubes, then outline the steps to transform a 2D into a 3D application, and report the findings from assessing 3D fluency in two schools.

2. AgentCubes: an Incremental 3D authoring environment

AgentCubes is a 3D rapid game-prototyping environment that enables even 10-year-old children to make simulations and games in just a few hours. While simple

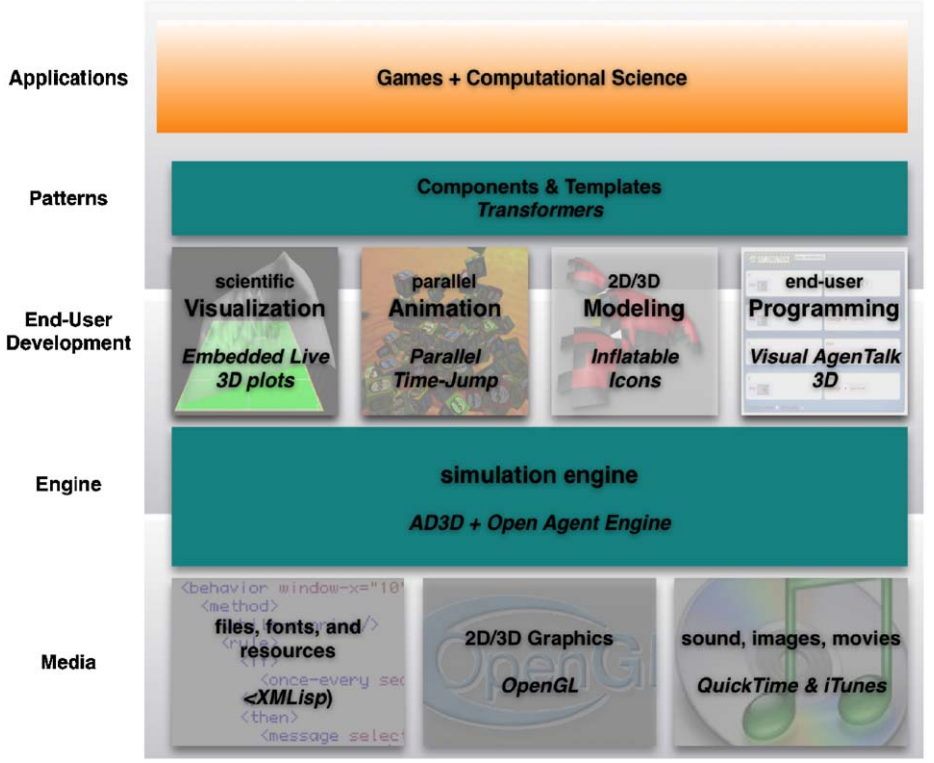

Fig. 1. The AgentCubes technical architecture.