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Computer animation data management: Review of evolution phases and emerging issues

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ABSTRACT

The computer animation industry has been booming and prospering in recent thirty years. One of the significant changes faced by this industry is the evolution of computer-animation data and, yet, extant literature has offered very little insights into the evolution process and management issues pertinent to computer- animation data. Hence, many questions have surfaced in the extant literature of computer-animation data management. For example, *to what extent has the data content expanded in terms of quantity and quality? To what extent has the information technology used to store and process the data changed? To what extent have the user and the community groups diversified in terms of their nature and number?* Knowledge pertaining to these issues can provide new research directions to academics and also insights to practitioners for more effective and innovative management of computer- animation data. This conceptual paper, therefore, takes the pioneering step to address these issues by proposing four factors prudent for examining the evolution phases associated with computer-animation data management: technology, content, users, and community. Next, this paper presents a conceptual framework illustrating the interdependent relationships between these four factors together with associated theoretical and managerial issues. This paper, albeit limited by its conceptual nature, advances the extant literature of computer animation, information system, and open-product model.

1. Introduction

Through a long history of development (Collins, 1997; Magnenat Thalmann & Thalmann, 1996), computer animation has become a prospering industry characterised by high growth: the total market revenue of the computer animation industry was reported to be around USD122.20 billion in 2010 and is forecasted to reach USD242.93 billion in 2016. The compound annual growth rate (CAGR) of the global animation industry is estimated to have risen by 12.94% in recent years (Deloitte, 2010; Markets & Markets, 2011).

Given the rapid growth of the computer animation industry, practitioners are faced with many challenges and amongst them include the constant and speedy generation of data, in mammoth volume, and from varied sources. For example, *Lune et le Loup* (2014), a French short animation film in 2014, it's running time is only 6.26 min while the animation data of all the frames reached up to 1.5 TB. Some individual frames of the movie *Interstellar* (2015) took up to 100 h to render, and resulted in 800 terabytes of data to create the satisfactory visual effects. Varied parties were involved in co-producing, co-using, and co-sharing the huge volume of animation data, including visual effects supervisor, a team of 30 people at the visual effects company, a theoretical physicist that served as scientific consultant, and executive producer/s. Consequently, in future film animation will rely more heavily on technology for data processing and management. Both the current and future modus operandi of animation data management urgently call for re-thinking and re-designing in order to address the escalating amount of the animation data more effectively.

There is a disconnection between business practices and academic research in relation to computer-animation data management, especially in relation to its evolution phases. Extant literature of information system offers little insights into the evolution of computer animation system related to issues such as, for example, the extent to which information system used to manage animation data has changed, the extent to which the animation data content has expanded, and the nature of the user and community groups has diversified. The purpose of this paper is twofold, that is, to:

1) address the disconnection between business practices and academic research in relation to computer- animation data management. More specifically, it reviews relevant literature to

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identify the evolution phases relating to computer-animation data management;
2) propose a list of emerging issues, together with research and managerial insights, relating to computer- animation data management.

The rest of this paper is structured in three parts: the next section reviews the animation data evolution based on different phases. Emerging issues pertaining to the computer-animation industry are presented in the following section. Finally, an open production model is presented to illustrate the animation data evolution.

2. Literature review

To critically examine and insightfully explain how animation data management processes and practices have evolved over the three decades, the literature review of this conceptual paper drew upon the systematic procedure used by Soomro, Shah, and Ahmed (2016), which comprises three key stages: searching the literature; selecting the literature; and analysing the identified literature.

2.1. Searching the literature

In this stage, Soomro et al. (2016) emphasized the issues of reliability and validity, whereby reliability is derived from meaningful keywords used for the literature search, selected databases, publications, and the covered period, and validity is derived from meaningful articles included and reviewed for addressing the research objectives. Drawn on these suggestions, the literature search of this paper began with the identification of the key words relevant for addressing the research questions via discussions between the researchers. Five key words were identified, namely, data management, animation production, animation data, animation industry. The discussions also yielded four databases and one search engine pertinent for the literature search: ACM Digital Library; IEEE Explore; EBSCO; Science Direct; and Google Scholar. The literature search covered the period of thirty years, whereby computer animation gained popularity or attention in the mass media after 1990s. The keyword search involved using several terminologies: “data management” OR “animation data” OR “animation production” (independently and collectively); “data management” AND “animation industry” OR “animation production”; “media data” AND “animation industry” OR “animation production”. To obtain additional eligible articles; the reference lists of the filtered articles were also checked.

2.2. Selecting the literature

After downloading, the list was checked for repetitions and duplicate articles were removed from the list. Next, the abstract of each article (or the introduction of a book chapter or a report) was perused and further filtering took place. Selection of meaningful articles was based on agreed inclusion and exclusion criteria. More specifically, full-text articles published in international academic peer- reviewed journals or in international scientific conferences were included. Book chapters by reputable authors, and trade reports (e.g. market and company reports) by credible sources were also included. However, conference proceedings with abstracts only and dissertations were excluded. Moreover, included articles must have either conceptually discussed or empirically examined the topics of data management and/or media data within the computer animation context. Studies examined data management, or those that focused on media data, but did not specifically relate to computer animation were excluded. Only articles published in the English language were included. To determine articles’ relevance to the context under study, abstracts were perused (for book chapters or trade reports, the introduction was read). Consequently, a total of 85 articles were deemed meaningful for the literature review of this paper (see Table 1).

Table 1
List of data bases and search engine used for literature search.

S. No	Name of database/search engine	Number of articles
1	ACM Digital Library	7
2	IEEE Explore	24
3	EBSCO	11
4	Science Direct	15
5	Google Scholar	28

2.3. Analyzing the identified literature

Three researchers independently reviewed the 85 included articles, and then compared and contrasted their findings. Divergent views on findings were resolved via discussions, and their findings were grouped into three convergent themes: evolution phases of computer-animation data management; emerging issues; and open-production model involving multiple stakeholders. Each of these convergent themes is discussed in detail next.

3. Evolution phases of computer-animation data management

Different from the conventional hand-drawn animation, computer animation uses computer graphics to generate animated images. Benefited from the development of computer science, encompassing a variety of techniques, such as keyframe animation and inbetween (Lasseter, 1987), and currently commonly used motion capture and simulation (Parent, 2012), animation could be produced in a cost- effective manner with higher quality. Computer technology has revolutionised the production of animation. Before the 1980s, animation production typically took the form of traditional hand-drawing production mode. After 1980s, the computer animation production accelerated, and was attributed to the computer hardware development. Since then, data has become an essential part of computer animation, and has evolved to be more complex and mammoth in nature and this phenomenon is coined as the birth of “Big Data” (Manyika et al., 2011; Shacklett, 2014). The word “big data” stated in this paper mainly refers to the massive volume of animation data rather than the broad term for large/complex data sets/data analysis used in current information world to provide enhanced insight and decision making in general meaning.

The literature review alludes that the evolution of computer animation data consists of four phases: phase 1 (the 1980s), phase 2 (1990–2005), phase 3 (2006–present) and the “big data” phase (next generation) as illustrated in Fig. 1. Each of these evolution phases is characterised by four dimensions: Technology, Content, User and Community, which finally lead to an Open Production Model for computer animation depicted in Section 5.1.

3.1. Phase 1 (the 1980s)

In this phase, technological innovation in computer science greatly stimulated computer animation development and production. A most important advance is the invention of the computer hardware that significantly promoted the computing power and provided a strong foundation for computer animation production. In the early 1980s, Silicon Graphics, Inc. (http://www.sgi.com/) was founded in California by Jim Clark. *Geometry Engine*, a powerful semiconductor chip and the IRIS (Integrated Raster