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Organ Printing as an Information Technology

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Abstract

Organ printing is defined as a layer by layer additive robotic computer-aided biofabrication of functional 3D organ constructs with using self-assembling tissue spheroids according to digital model. Information technology and computer-aided design softwares are instrumental in the transformation of virtual 3D bioimaging information about human tissue and organs into living biological reality during 3D bioprinting. Information technology enables design blueprints for bioprinting of human organs as well as predictive computer simulation both printing and post-printing processes. 3D bioprinting is now considered as an emerging information technology and the effective application of existing information technology tools and development of new technological platforms such as human tissue and organ informatics, design automation, virtual human organs, virtual organ biofabrication line, mathematical modeling and predictive computer simulations of bioprinted tissue fusion and maturation is an important technological imperative for advancing organ bioprinting.

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1. Introduction

Organ printing is a biomedical variant of additive manufacturing technology [1-3]. It could be define as a computer-aided layer by layer additive biofabrication of functional 3D tissue and organ constructs based on digital model with using tissue spheroids as self-assembling building blocks [3]. It is obvious (based on this definition) that it is not possible to bioprint functional human organ constructs without correspondent digital model or simply speaking without organ blueprint. Design of digital models of physical objects using computer-aided design (CAD)

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software is a classic example of information technology. In this context it is not a big surprise that 3D bioprinting is considering now as an information technology (Fig. 1) [4]. Organ printing is a rapidly evolving novel biomedical technology on interface of biological and engineering disciplines. The information science and technology is a critically important essential integral component of emerging 3D bioprinting technology.

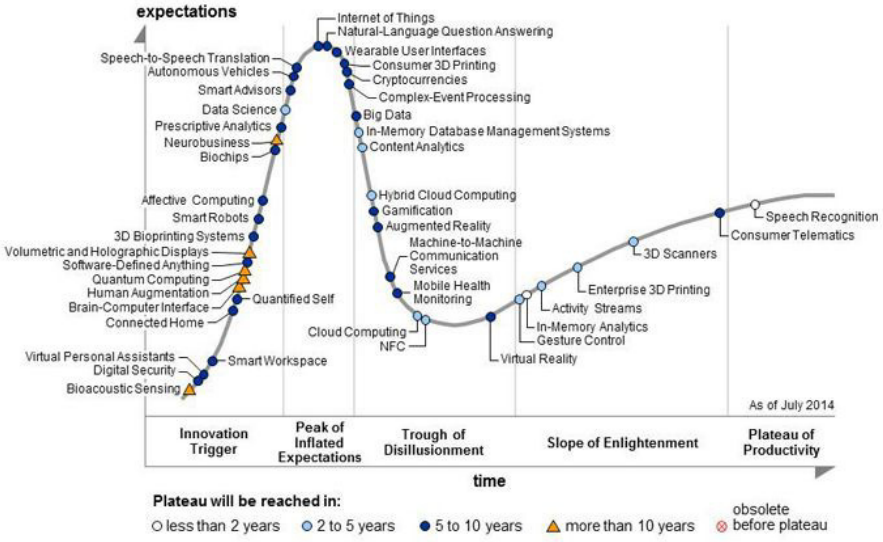

Fig. 1. Gartner report: 3D Bioprinting as an Information Technology [4].

3D bioprinting technology similarly to more established 3D printing or additive manufacturing technology includes both hardware (3D bioprinter) and software (digital model). 3D bioprinter is a robotic dispensing device which precisely place biomaterials and living cells or tissue spheroids and rods in three-dimensional space according to digital model. Software is a part of its operational control which enables robotic bioprinting of 3D tissue and organ constructs. It is logically that at initial stage of development of 3D bioprinting technology the hardware or 3D bioprinter attracted the main attention of researchers and bioengineers. However, we strongly believe that with increasing availability of 3D bioprinters (hardware) the research interest will gradually be more focused on development of software or digital model for bioprinted organs. 3D bioprinters are now commercially available and their price will be only reduced and they eventually became a cheap commodity.

As example, at least two software companies Autodesk (USA) and Materialise (Belgium) are already trying to position itself as developers and suppliers of software for 3D bioprinters. In this paper we will illustrate that organ printing is indeed an information technology and that application of existing information technology and computational tools as well as the development of new software is an important technological imperative for advancing organ bioprinting.

2. Conceptual Framework

Concept of organ printing has been invented already one decade ago [5]. In essence it is a biomedical application of rapid prototyping technology or additive manufacturing. The additive manufacturing enables transforming digital model of object into physical reality. Thus, information technology is an integral part of organ printing. Information is a critically important aspect of 3D bioprinting technology but it still got rather insufficient attention of researchers and engineers. Meantime, computer-aided tissue engineering is gradually evolving and there is even already book on this topic [6]. Unfortunately, up to now computer-aided tissue engineering predominantly has been focused on design of solid scaffolds for tissue engineering construct and in this context could not be even considered as a really revolutional 3D bioprinting technology because BIOprinting is actually missing in this approach. The concept of