Reverse Engineering in Rehabilitation

B

Emilia Mikołajewska
Nicolaus Copernicus University, Poland

Marek Macko
Kazimierz Weilki University, Poland

Zbigniew Szczepański
Kazimierz Wielki University, Poland

Dariusz Mikołajewski
Kazimierz Wielki University, Poland

INTRODUCTION

Reverse engineering is relatively novel technology, which may revolutionize clinical practice in rehabilitation. This technology may constitute next step toward patient-tailored therapy, providing customized medical products increasing effectivity and accessibility of rehabilitation procedures and decreasing cost of manufacturing and time of delivery. Such opportunities need separate research, assessment of associated threats, and dedicated solutions.

In this chapter authors investigate the extent to which the available opportunities in the area of application of reverse engineering in rehabilitation are being exploited, including own concepts, studies and observations.

BACKGROUND

The additive manufacturing (AM), called also 3D printing or stereolitography is relatively novel technology developing since 1980s. It constitutes iterative technology based on construction the real objects layer by layer, translating this way digital file (digitized object) into a solid object. Features of such object depend on technology and material used to print, but number of both of them rapidly increases, providing important alternative for traditional manufactiring techniques. Moreover some objects have unique features (e.g. shapes) not comparable with products of traditional manufacturing.

Recent editorial article by Maruthappu & Keogh paid particular attention to potiential of 3D printing applications to transform healthcare technologies and organization. Authors divided possible healthcare applications of additive manufacturing into three main groups:

- Internet as decentralised store of blueprints (drugs, equipment, devices, and even body parts) for Early patients-tailored interventions, much quicker and cheaper than traditional delivery solutions,
- Patient–tailored therapy based on medical imaging combined with 3D printing,
- Engineering of 3D printed tissues (Maruthappu & Keogh, 2014; Murphy & Atala, 2014; Seol et al., 2014).

Further implementation of reverse engineering needs additional interdiciplinary research (including randomized controlled trials on patients where available), dedicated methodology, careful assessment of opportunities and threats as far as dedicated solutions.

DOI: 10.4018/978-1-5225-2255-3.ch045

Reverse Engineering as A Complex Process

Reverse engineering is regarded as quick and cost-effective method of creating functional or nonfunctional copies of existing objects. Process of reverse engineering for rehabilitation purposes is unified to several subsequent stages covered by semi-automated process:

- Digital acquisition of the 3D geometric data: directly from the patient or based on his/her medical records (e.g. using computed tomography – CT or magnetic resonance imaging – MRI),
- Modification/adaptation procedures,
- Creation of 3D model or final product on 3D printer and control of its feasibility: material features, shape, dimensions, patient comfort, etc.

Reverse Engineering for Rehabilitation Support Purposes

Rehabilitation aims at restoration of patient's functions to the maximum possible degree. Scientists and clinicians are aware that in such person the full capacity available in healthy people can not be achievable despite efforts of patient, therapists and caregivers. Increasing number of severely ill, disabled and elderly people makes this task even more difficult. Thus there is still need for novel solutions increasing effectivity of the current rehabilitation procedures.

Rehabilitation should be common, early, comprehensive, and continuous. Reverse engineering products are beneficial for a wide variety of applications in the area of rehabilitation providing:

- Short track between measurements in particular patient and final ready-to-use patient-tailored product (assistive technology device, drug, artificial organ),
- The same quality, geometric accuracy and shape reconfiguration possibilities as original product (e.g. in the case of replacement),
- Features modification possibility (according to the current patient's need) by therapists/manufacturer,
- Low price thanks to cheaper commercial technologies of 3D printing, lack of transport and storage costs,
- Cost-effective production of customized products.

Reverse engineering can provide cells based bones or soft tissues for modelling, testing and therapy purposes thanks to the use of bio-ink (composition of cells and hydrogel materials). Moreover assistive technology products can be cheaper and patient-tailored. Use of such solutions can provide higher therapy efficacy, life quality in patients with severe disorders, usually associated with long-term disability. The huge breakthrough in neurology, neurosurgery and neurorehabilitation can cause novel nerve repair technique: microstructured scaffolds to promote nerves regeneration (Chang et al., 2008; Zhu et al., 2008).

SOLUTIONS AND RECOMMENDATIONS

There is need for further development of interdisciplinary collaboration to identify possible threats and limitations emerging from novel applications of the reverse engineering in everyday clinical practice. Current limitations in the area of reverse engineering cover following topics:

- Ethical issues concerning use of living tissue to print artificial organs, and possible tissue modifications,