Discussing the Challenges in Creating an Online Library of 3D Printable Assistive Living Devices

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Abstract

Our goal is to identify the barriers and process of creating a digital library of medical assistive devices that can be personalized and 3D printed for people living with disabilities. In the past, and true today, traditional manufacturing methods make it cost prohibitive to create personalized devices to assist individual patients with their activities of daily living (ADL). Now and in the immediate future, availability and affordability of 3D printing makes it feasible to produce low volumes of devices, on demand, using a distributed manufacturing model. This document discusses three main challenges to originating and creating this library: (1) the validity of using 3D printing for assistive device technology, (2) organizational approaches to optimize the library accessibility, and (3) creating an intuitive search method to navigate the library.

Introduction

Almost 20% of Americans live with some level of disability, each with their own challenge to overcome in order to complete their ADLs. Traditionally, people tried to address these needs by searching through online medical superstores or their local occupational therapy (OT) office. However, because the cost of patenting, prototyping, manufacturing, and selling these devices can be significant, there are still many areas of need in the assistive technology realm that are currently cost prohibitive to address.

With the recent advances in additive manufacturing (commonly referred to as 3D printing), a new method for producing and distributing these devices has emerged. Instead of incurring the huge upfront costs of manufacturing these devices centrally, 3D printing allows for a user anywhere around the world to download a device file and print it at any of their local 3D printing locations, reducing production costs.

We propose the creation of an online library of 3D printable assistive living devices. Users could search the library and download a device based on their functional status, body part, or desired activity. They could then take this file to any 3D printing facility to print for themselves. This poster discusses the challenges in creating such a library.

3D Printing

Distributive Manufacturing

3D printing is the process of making an object layer-by-layer, from the bottom up, one cross-section at a time. This allows for any printer to print almost any object without special equipment. Instead of paying upfront to manufacture the device and needing to recuperate costs, all the manufacturing is done locally by the user, eliminating distribution in the process as well.

Customization

The digital nature of the devices also allows for quick customization of the devices. By incorporating biometric measurements directly into the 3D model, a user can measure the width of their hand, input it into the device's digital file, and then download a device that matches their hand (see Figure 1). This ability to customize devices extends even further to the users, as they will be able to make their own changes to the device and reupload it to the library for others to use.

Safety Parameters

Device files for 3D printing use finite element modeling (FEM) to apply stress to them, and report device failure loads. Digital safety testing can accelerate device approval by a committee charged with ensuring each device is safe to use.

Taxonomy

Database Requirements

The definition of disability has changed considerably over the years. Today, the ADA defines disability as someone who has a physical or mental impairment that limits "major life activities," someone with a history of such impairment, or someone who is regarded as having such an impairment. While the definition of disability is broad, the scope of our library will not cover the entire spectrum of disabilities. The majority of 3D printers that would be available to our users print in plastics (ABS or PLA), and the print bed is around one cubic foot. Therefore, our library will mainly be geared towards people who have disabilities that can be helped with small, mechanical devices that can withstand mild-moderate weight loads.

Existing Taxonomies

There are existing taxonomies that attempt to classify disabilities and assistive technologies. One of the most complete versions is the International Classification of Functioning, Disability, and Health (ICF) made by the WHO, which attempts to combine both environmental as well as personal factors in describing disabilities. Other classification systems are used by the large online retailers like Performance Health, which focus on different activities when organizing their products, rather than the disabilities themselves.

Our Taxonomy

Our classification system will have two interconnecting taxonomical trees. The first tree will represent the user (and the disabilities they identify with), and have devices sorted according to the data collected from the medical avatar (strength, ROM, sensation, etc.). The second tree will be focused on activities of daily living (grooming, eating, transport, etc.). This will allow users to search for specific devices based on activity type, or browse a variety of devices across all activities that might be useful for them based on the data from their avatar.

The Medical Avatar

Usage of the Avatar

Once the avatar is created, all the information pertaining to the user's disability will be encompassed in the avatar. At this point, the user will be able to search/filter out devices in the database that could improve their quality of life. The medical avatar eliminates aimless browsing and obscure keyword search.

Creating a Medical Avatar

An avatar is a digital representation of a person, created by that person. Traditionally, they were used to represent a person online or in a video game. However, an avatar can also be used to collect and store medical data about a user. A medical avatar can also eliminate the complexity of medical terminology by creating a graphical interface with visual feedback to align avatar and user body shape, range of motion, and strength.

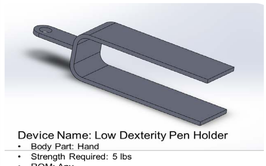
Components of the Medical Avatar

The medical avatar will consist of three main components: visualization, range of motion (ROM), and strength. The visualization of the avatar is the most important, as it is what the user actually sees. In addition to characteristics like gender, height, weight, and facial features, the user can edit their avatar to include other medical conditions, such as a missing extremity, or medical equipment such as a walker or wheelchair. Once the user has made an avatar that looks like them, they will then be able to input the ROM and strength of each extremity to describe their functional status.

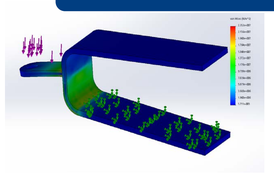
Acknowledgements

I wish to thank my mentor Dr. Jonathan Lifshitz for his advice and support both on SP matters and otherwise, Dr. McEchron for his guidance throughout the SP course, Dr. Patti Christ and the OT and PT departments at NAU, and the UACOM-P library staff.

Library Workflow

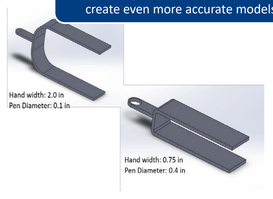


Any medical assistive living device can be uploaded to the library. The uploader will label it according to activity type, body part, and functional status.

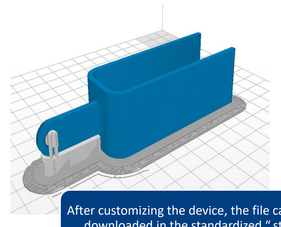


Once the device is uploaded into the library, FEM can be used on the device to test the level of force it can accommodate and whether it is safe to use.

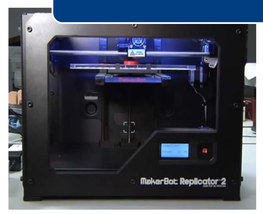
When a user goes on the site to find a device, they will have the opportunity to create a medical avatar. This contains parameters such as strength and ROM, which are then used to find devices that would be useful for the user.



Once the user finds a device they are interested in, they will be able to input their own physical measurements, which will allow the device to be scaled to fit the user. In the future, 3D scanners could be used to create even more accurate models.



After customizing the device, the file can be downloaded in the standardized ".stl" format. With the download will come recommended instructions for build material, density, and orientation.



The .stl file can then be uploaded into any 3D printer, and after a few minutes the device will be ready to use!