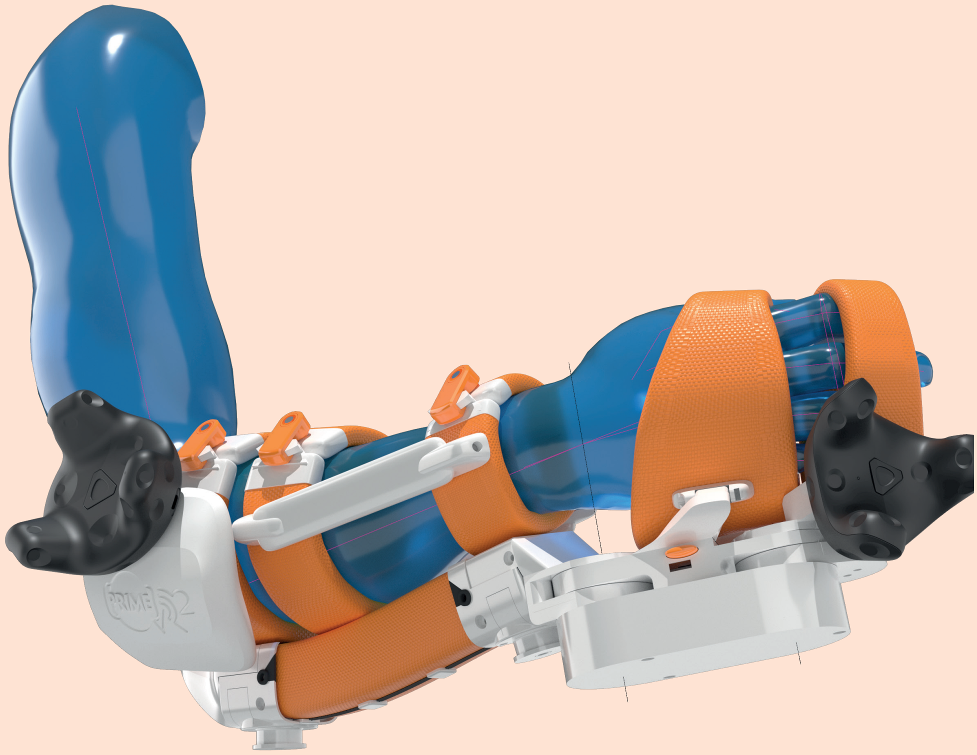
PRIME-VR2 - H2020 Project
Personalised recovery through a multi-user environment

May 2022 - Issue #09

NEWSLETTER

VR for Rehabilitation

WELCOME TO OUR NEWSLETTER



PRIME-VR2 PRIME-VR2 acknowledged for its excellence in innovation

The Consortium is very proud for its recent achievements! The bespoke controller for upper limb rehabilitation developed by the partners has been acknowledged as leading innovation and has been highlighted on the EC's Innovation Radar. Besides, the project workshop on Design for Additive Manufacturing hosted at the University of Malta in March was a real success!

PRIME-VR2 Highlighted by the EU Innovation Radar

The PRIME-VR2 project has received notification from the European Commission informing the project that its work on “Bespoke controllers for upper limb rehabilitation in virtual reality“ has been highlighted on the EC’s Innovation Radar. This work led by the University of Strathclyde, Loud1Design and the University of Malta, has been chosen as an example of a leading innovation arising for EU funded research projects. In addition, University of Strathclyde, Loud1Design and the University of Malta have all been identified as ‘Key Innovators’ in the development of this innovation and will be highlighted on the Innovation Radar platform.

The Bespoke controllers for upper limb rehabilitation in virtual reality were highlighted as being Tech ready under the Mark Maturity section along with having a noteworthy Market Creation potential into the future. Tech Ready solutions as noted as innovations progressing on technology development process (e.g., pilots, prototypes, demonstration) and are considered ‘Advanced on technology preparation’. Moreover, a number of addition opportunities will be provided to Key Innovators, including a hosted business profile on the Radar platform to highlight their businesses innovation actions and the opportunity to apply for “go to market” training and support from Dealflow.eu, the support action of the Innovation Radar financed by Horizon Europe.

In the near future, this innovation will be published on the European Commission's Innovation Radar platform, along with the names of the beneficiary organisation, in the project identified by Innovation Radar as a 'key innovator'. Details of the EU-funded project the innovation was developed within, will also appear on the platform, celebrating this success of PRIME-VR2 to date. The information will be accessible to the public and join the 7600+ EU-funded innovations already showcased on the platform. The Innovation Radar platform builds on the information and data gathered by independent experts involved in reviewing ongoing research and innovation projects funded by the EC, with these experts providing an independent view regarding the innovations in the projects and their market potential.

The Innovation Radar is a European Commission program to identify high potential innovations and innovators in EU-funded research and innovation projects. Its goal is to allow every citizen, public official, professional and businesspeople to discover the outputs of EU innovation funded projects and establish future collaborations with innovators who could follow in the footsteps of companies such as Skype, TomTom, ARM Holdings, all of whom received EU funding in their early days. The platform is a first step in achieving such ambitions by making information about EU-funded innovations from high-quality projects visible and accessible to the public via the platform.

PRIME-VR2 are proud of this acknowledgment, the excellent work completed by University of Strathclyde, Loud1Design and the University of Malta, and foresee that their inclusion in this initiative will open up new opportunities partnerships with business or academic organisations and support additional interest from potential customers or investors in the projects innovations.

The 2022 Design for Additive Manufacturing (DfAM): Future Interactive Devices (DEFINED) Workshop
Sliema, Malta, March 2022

The Department of Industrial and Manufacturing Engineering (DIME) at the University of Malta has hosted the first international workshop on Design for Additive Manufacturing (DfAM): Future Interactive Devices (DEFINED), between the 17 and 18 March, 2022.

The goal of the workshop was to explore the mindset of adopting an interactive product design approach in Additive Manufacturing (AM) together with the exploration of integrating sensing, display, and illumination elements to be directly embedded in the architecture or mechanical structure of these interactive products. Using these elements, unique product architecture, novel user-interaction techniques, bespoke and modular industrial designs, and embedded optoelectronic components can be digitally fabricated for rapid, high fidelity, highly customised interactive devices. The workshop consisted of a number of round-table discussions covering topics such as principles to successfully design, fabricate and test future interactive devices, how to capture user data for bespoke AM products, how to embed sensors and electronics in 3D printed products, what is the impact of AM process maturity level on such artefacts, how to apply computational design approaches for AM and the feasibility of the AM process for mass customisation. Keynote speakers from the Department of Mechanical Engineering at the Politecnico di Milano, School of Design and Creative Arts at Loughborough University and the Atlas Institute at the University of Colorado participated in this two-day event.

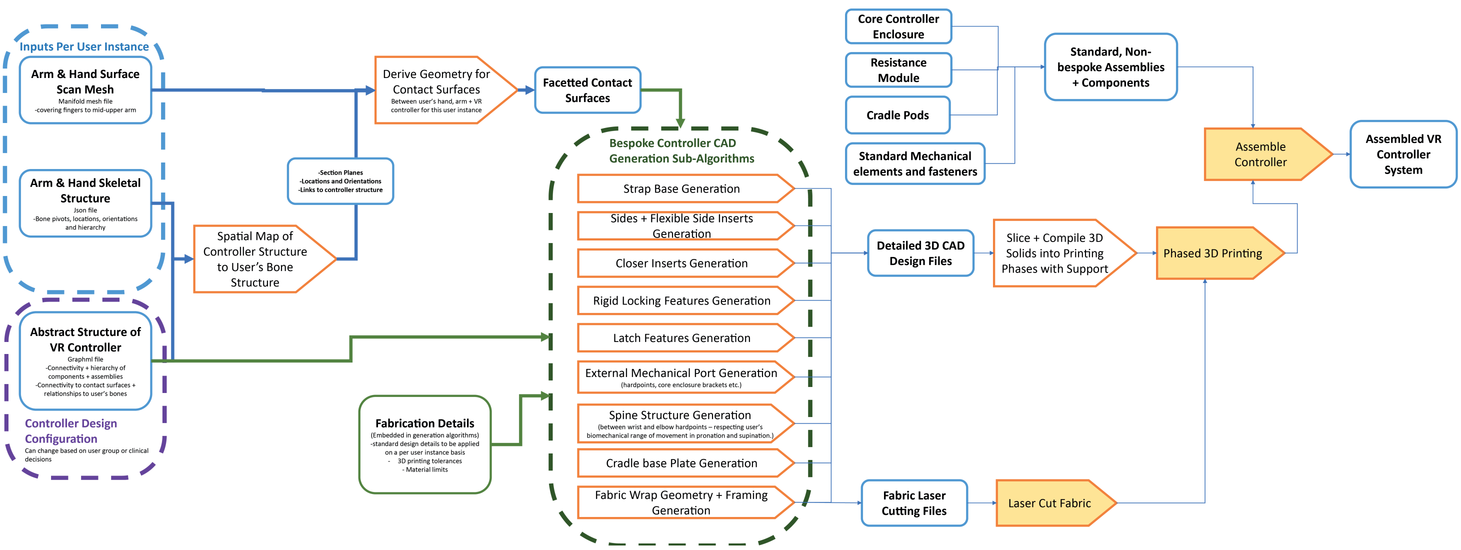
This workshop, which has been chaired by Prof Ing. Philip Farrugia, from DIME, has been organised as part of the PRIME-VR2 project aimed at developing innovative 3D-printed Virtual Reality (VR)-based bespoke controllers and the supporting IT platform for rehabilitation purposes. The DEFINED workshop event was supported by MakerFaire Malta, the Design Society, the Institution of Engineering Designers (UK) and the Design for Additive Manufacturing Network (UK). Further details are available at: https://www.um.edu.mt/events/defined2022.

Creating Bespoke Controllers that Respond to the Needs of the Individual

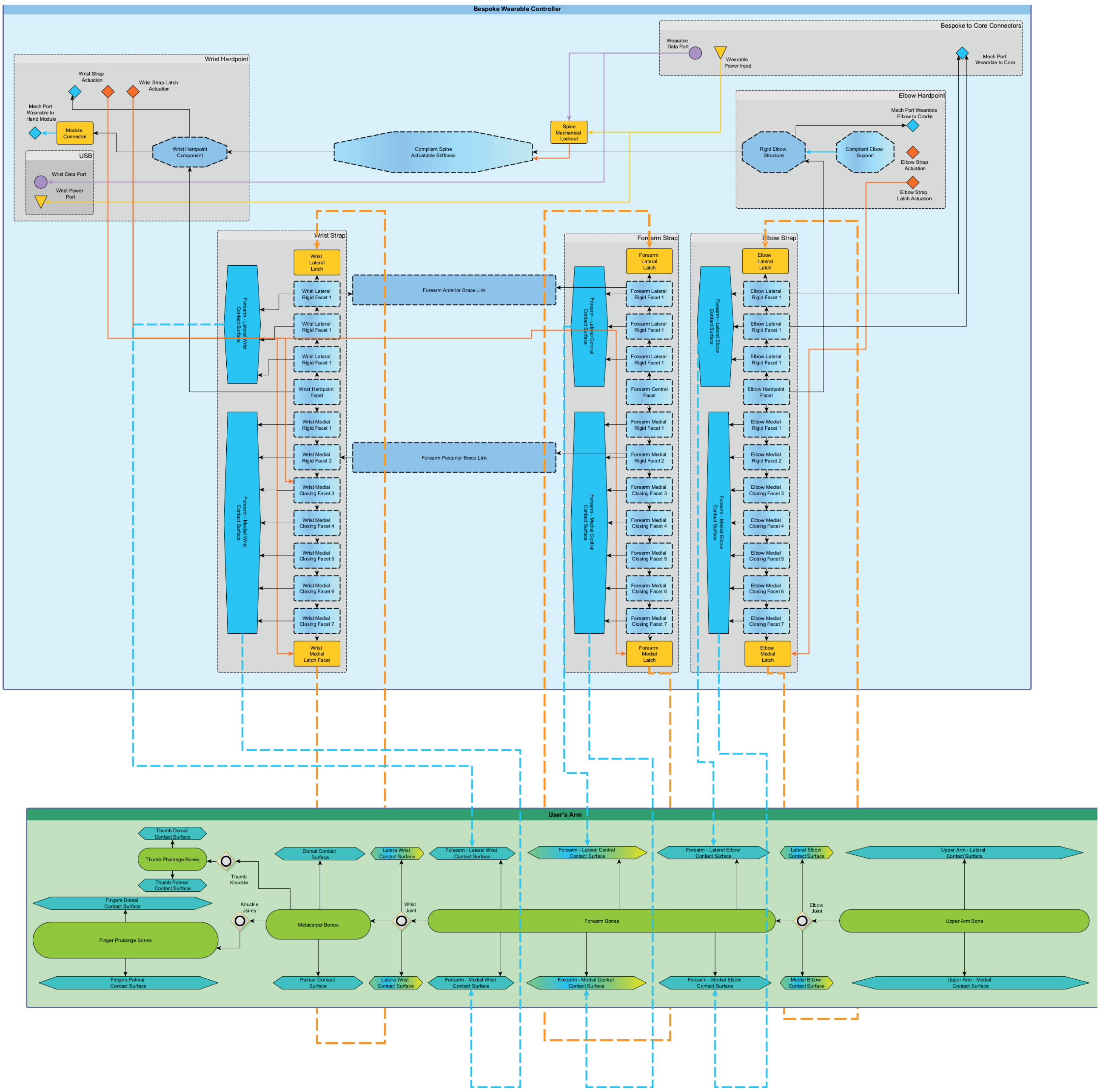
In targeting therapies in VR at the three living labs and their patients, we are dealing with a disparate array of conditions which has a fundamental impact on the physical controller that the user will interact with to carry out their therapy programme. Typically in design and development of a medical product we take into account the anthropometry of the target users and ensure that none of this group is excluded from its use. This is important not only for the measured dimensions we take from the anthropometry but also the wider human factor concerns and ergonomic issues which may prevent a user from performing expected tasks comfortably. This would typically result in one set of design documentation (3D CAD models, specifications and a bill of materials) that would be progressed towards production. However, in the scope of the PRIME-VR2 project the range of conditions: stroke recovery, dystonia and musculo-skeletal injury, also potential ranges from teenager to octogenarian, result in a different approach being required.

The Algorithmic Approach to Design

The approach developed here at Loud1Design was to find a software agnostic approach to defining the wearable controller's required specification and design that was high level enough to capture all the necessary information for production without being too general as to lose meaning. This abstract definition allows the design intent to be captured and documented free of any specific dimensions or coordinates. This allows the design to be fully implemented as a package of 3D CAD models only once we have the anthropometric and biomechanical data of the individual user.



This is the key link between WP3, tasked with developing this algorithmic approach and WP2, focussed on capturing a full description of the anthropometry and biomechanics of each patient. The overview of the algorithmic consists of three key inputs: the arm and hand surface scan mesh, the arm and hand skeletal structure and the abstract structure of the VR controller. This last element has been implemented as a graphml file as shown below, where the abstract structure is defined as classes of components that are linked to each other in a hierarchy. So for example, we have a series of sub-assemblies of class “strap” which has instances of “wrist”, “finger”, “elbow” etc. Each strap is composed of a series of “facets” which may have in turn its own properties that indicate if it has a latch or will be rigid. The use of graphml, a subset of the XML standard means that the design intent remains software agnostic, it also means that this file and definition can be easily manipulated through web-based applications making it ideally suited to interaction with the User Profile Toolkit being developed for use by the clinician. Direct manipulation of the graphml representation could include for example the removal of the forearm strap for the dystonic user group. This strap acts as a brace to carry the forces imparted by the therapy exercises themselves and is not necessary for this user group. In this way, high level design decisions can be quickly implemented on a case by case basis as part of the workflow.



Also important to note is that the structure of the user's arm is represented in an abstract way in this process showing explicitly the surfaces of the user's arm we expect to come into contact with the wearable controller. These inputs to the algorithm are then loaded into the 3D CAD software "Rhino 3D" using custom code developed here at Loud1Design to then generate the necessary 3D CAD required for fabrication of the bespoke wearable. The structure and its connectivity is then literally pulled onto the surface of the scan data in a form finding process. This is what we have dubbed the "spatial embedding" of the abstract design structure in 3D space, with this we then have all the spatial information required to generate discrete concrete geometries which implement and realise the design intent.

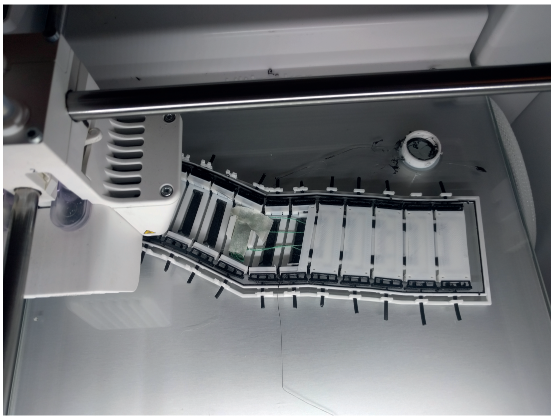
The care required to decompose the design into these classes of objects has led to a highly modular approach to the controller design where we are separating out the bespoke elements from sub-assemblies that can be mass produced in future iterations of the PRIME-VR2 controller.

Developing a Suitable Fabrication Process

In fabricating the bespoke wearable elements of the controller we make use of Additive Manufacturing (AM) technologies in order to take advantage of the freedom from any tooling requirements that are seen in mass production allowing us to create one-off elements economically. In designing for AM one has to be very careful however of the limitations and weaknesses of any given process. Here we have targeted the use of Fused Deposition Modelling (FDM)/ Free Form Fabrication (FFF) as it is the most widely available and cheapest process in terms of cost of machines, printing materials and also operational costs.

With any AM process it is often underestimated the amount of time required to post-process the resulting workpieces to finish them to an acceptable level. For the FDM process this is particularly the case for the removal of support material and the clean-up of the relatively rough surface finish they produce. It has been key to our approach here to design the bespoke wearable to be printed with no support material and to largely encapsulate the printed elements within a fabric skin.

At Loud1Design we have developed a "phased printing" process of layering multi-material prints to ensure strictly no support material, such that the resulting workpieces are simply snipped from a sprue and are ready to use. This phased approach has also enabled the inclusion of a layer of fabric around the sub-assemblies of the bespoke wearable, providing a tactile and comfortable interface



Lessons Learned and Transferable Technologies

As we progress through the final year of the PRIME-VR2 project the algorithmic design workflow and AM processing techniques continue to be refined and developed, however key learnings are emerging. We see the use of an abstract design definition which is spatially embedded only once paired with the knowledge of the individual user as an approach that could have potential applications across the domain of personalised healthcare.

The innovations here in developing phased printing of FDM enables the fabrication of AM parts not merely as prototypes but as valid multi-functional sub-assemblies, and this could have wide applications in many sectors. The developed bespoke strap and brace elements of the PRIME-VR2 controller themselves should have many applications in the field of prosthetics and orthotics and beyond into sports and fitness products.

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NEXT ISSUE:

In the next issue, we will report on the conference held in Pisa (UX4VRehab) and share our progress.

October 2022

The Conference 'User Experience Design for Virtual Rehabilitation' (UX4VRehab) will be held on the 13th and 14th of October, 2022 at Le Benedettine, Pisa both on-site and on-line.
For more information: https://conference.prime-vr2.eu/_program/

CHECK THE WEBSITE REGULARLY FOR MORE NEWS, DOWNLOADABLE CONTENT AND INFORMATION!

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PRIME-VR2 is on the Virtual Reality Helix

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