A prototype for a scalable virtual technology museum

Denis Roegel*

17 September 2022

This brief note aims at offering some thoughts and advices on the topic of virtual technology museums.

1 Virtual reality

Virtual reality (VR) has been around for many years and is more and more extending beyond the world of games. More and more exhibitions allow for VR experiences, and sometimes even Augmented Reality (AR) experiences. For some recent examples, consider the VR experience at the "Machu Picchu and The Golden Empires of Peru" exhibition that opened in Boca Raton in 2021 and recently travelled to Paris, or the digital experiments at the Œuvre Notre-Dame museum in Strasbourg in 2022. These examples demonstrate various uses of virtual reality, that either supplement the reality, or provide immersive experiences.

Virtual reality adds a layer to the world, and can provide visualizations for scenes that are difficult or impossible to visualize otherwise. Virtual reality is more than merely displaying something on a screen, it is putting the viewer at the center of the action, and providing a stronger interaction. It is also a way to provide a personalized interaction, one that the viewer takes on his own path.

Virtual reality in museums is of course not new, but immersive devices have tremendously developed in recent years. There is now a vast literature about designing virtual museums within museums, or about the technologies involved in designing virtual museums. But very little has been written on the particular case of technology or craft museums.

*roegeld@gmail.com, https://roegel.wixsite.com/science

2 The needs of technology museums

These are museums showcasing cars, airplanes, machines, instruments, and in fact a variety of objects having some complex structure which usually can only be fully, or at least better, understood when seeing them in motion from various angles, or seing some details, and so on. It is for instance very difficult to understand how a car engine works, even when opening the hood of car, and even with special cutouts. Some details can be gleaned, but a lot will remain shady. This is even worse with jet engines or other more complex machines. There is a need to provide more information, to show various operations, to show plans, etc., and to adapt all these informations to the viewer. There are probably not many museum that can claim to have reached this objective of providing to each visitor everything that this visitor would like to have in order to understand a given machine or mechanism. I don't know of any museum in France that has managed it, although there has been progress.

Virtual reality can provide what the reality does not provide, namely the means to see a motor running, or to explain it in detail. In fact, for many machines, there are already very good explanatory videos on *youtube* or other places.[1] But these videos are not interactive, and they only tell one story.

3 Towards a fully immersive museum

The experiments which have been conducted so far provide a number of stops in museums where virtual reality or other forms of enhanced digital media can be experienced, but the digital experience is not a global one. On the other hand, when we visit museums, we are often given audioguides, which provide contextual audio that supplements the various stages of an exhibit. In some cases, the audio supplements a video part, but which varies from stage to stage. Such is for instance the experience provided at the Hans Christian Andersen museum in Odense (Denmark). But why should we stop at audio? It is easy to imagine something that will provide a different video stream for each visitor. This may in fact already exist in some museums, although I am not aware of it at the moment. Of course, if each user has a headset and walks around without looking at the reality anymore, one may question the need for an actual museum...

[1] Good examples are the videos by Sabin Mathew (Lesics on *youtube*), and Jacob O'Neal (`https://jacoboneal.com`), in both case made with Blender.

But there may be reasons to go that way, for instance because it provides an experience not found elsewhere, such as in a closed area of a larger museum, or also because it may be a way to show works that are not owned by the museum. In other words, one might imagine a museum displaying in some empty room a number of virtual objects that can only be shown digitally, because the museum does not own these works, or perhaps even because these works do not exist anywhere. In some cases, a museum might create 3D parts or other copies of works it doesn't have, for the purpose of enhancing the exhibit. But at the most extreme, one might imagine a museum containing only digital works in empty rooms. This does of course require among other things that the motions of the visitors are secured (with today's self-driving cars, that should not be a problem), but it also raises questions of the unicity of works of art. We are all used to attach a work to a place, in other words, we are used to deal with non fungible works. But if works become digital, we may then have to consider that the same work is visible and can be experienced in different places, in the same way as a movie can be seen in different places.

4 A virtual technology museum

Let us try to be more specific and imagine a virtual technology museum[2] with either real machines, such as motors, vehicles, clocks, etc., or perhaps merely the space for walking around digital versions of these machines. The idea is then be to have different machines in different places, such that the visitor, with an appropriate headset (or, more generally, an individual device), can examine and interact with each of these machines. For instance, one of these machines could be a clock, such as the former clock from Notre-Dame cathedral in Paris (figure 1).[3] Of course, when learning about machines, it will be important to also have some real machines, possibly some of them operational, but virtual machines may give some background or show parts that otherwise cannot be shown.

In fact, if there are only virtual works, one may question the need to space out the works. They could very well all be at the same place, and a visitor could examine them in some order, but without moving, or by staying mostly in one place. On the other hand, some works may be large (the Notre-Dame clock was 224 cm wide) and in order to get a real immersive

[2]There is, by the way, a site `www.virtualtechnologymuseum.com`, but it does not provide an immersive experience, nor does it contain any 3D rendering of machines.

[3]I have made the model of this clock in 2020 and it is available online at `https://github.com/roegeld/notredame`.

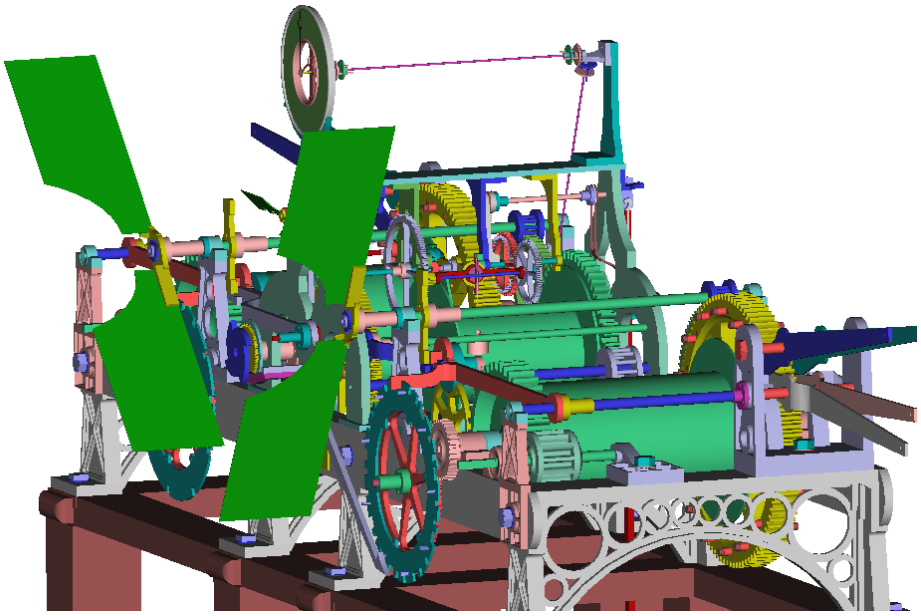

Figure 1: The 3D model of the Paris Notre-Dame clock.

experience, it may be useful to move around the object. Moreover, there is also a need to see several objects at the same time, like the objects on a museum's shelf, and to compare them. So, there is really a need to be able to interact with several objects at the same time, and perhaps even to move some objects, not only to move around the fixed objects. How should for instance tall objects be handled, or objects where the visitor may want to see above or below? It should perhaps be possible to raise or lower these digital works. And one may want to compare one specific side of an object with another side of another, or perhaps even visualize at the same time two or more sides of a given object. These are some of the challenges facing virtual reality in museums. In addition, an exhibit may be partly real, partly virtual, and there is the need to secure the navigation of the visitors, both with and without VR devices. The infrastructure of such a purely digital museum is clearly a difficult task and I will not go beyond wishing that such an infrastructure becomes reality. But one idea is certainly to organize a museum as cells, like a cellular phone network, and have individual devices connect to the cells and download in advance (as in an arithmetic pipeline) the 3D models or other data covered by these cells. For instance, if the museum is organized in rooms, the individual device should download the models of nearby rooms ahead of the arrival in these rooms. And conversely, models which are no longer in nearby

rooms should be freed from memory. There is a need to ensure that an individual device only knows about a limited number of works, and does not become overwhelmed by large amounts of data. As with the concept of "level of detail" (LOD) in video games, there is no need for an individual device to hold the data for an entire museum. Instead, such a device should be able to navigate and learn about the objects as the visitor moves around in the museum. In addition of automatic downloads, there may of course also be some downloads chosen by the visitor, and although an individual device does not need to hold the entire digital museum, the cells themselves should provide access to the entire museum.

It is of course easy to imagine an extension of this principle to the entire world, so that any object could be visualized in any place. This capacity to extend the experience on such a large scale is really what I meant with "scalable." A museum then becomes a mere place where the models of the universe can be accessed, but its very walled-nature tends to vanish. Instead, there may also be an increased focus on the interaction not only between the users and the objects, but between the users themselves, through the virtual reality. We are therefore not very far from the Metaverse.

5 The fundamental bricks

I assume that we will some day have an infrastructure such as the one described above, and hence that we will have the capability to set up what might be called a metamuseum or a hypermuseum.

But as a classical museum is not merely a building with walls, a metamuseum is also not merely an infrastructure of cells and individual devices. It does contain digital objects. There may be many such objects, including sounds, videos, texts, etc., but in the case of machines, 3D models represent the most important ones and perhaps the most complex ones. For instance, the clock shown in figure 1 is an assembly of 359 parts, some of which can move. Such an assembly is typical of a wide range of mechanisms, not only of clocks. Cars, trains, mills, instruments, etc., are some of many constructions which are built of smaller parts that fit together and of which some may be in motion and interacting with others. Of course, not all mechanisms are merely assemblies of rigid parts, and a machine may contain non-mechanical features, for instance electrical wires, or flows of gases, etc. But there is a whole range of objects that can be built merely by assembling simpler rigid parts, or mostly rigid parts. In addition, one should keep in mind that a 3D model is always a simplification. Neither

are all the atoms of an element shown, nor are all its features. When a steam machine is modelled, a piston may move, but perhaps the gases which cause the piston to move will not be shown.

The set of constructions which can be obtained by assembling smaller rigid parts is therefore a very important class of constructions, which does in fact also cover static objects, such as buildings, bridges, and so on. And even though some objects may not move in reality, we may actually make them move for explanatory purposes.

It is relatively easy to integrate models such as the one of figure 1 in a VR headset such as Meta Quest 2. Such an integration can for instance be done with the Unity game engine.[4] Each part can be provided as an OBJ file (for instance), loaded and animated. It is in fact not more difficult than creating a mobile application such as the one I made for the same clock, also with Unity (figure 2).[5]

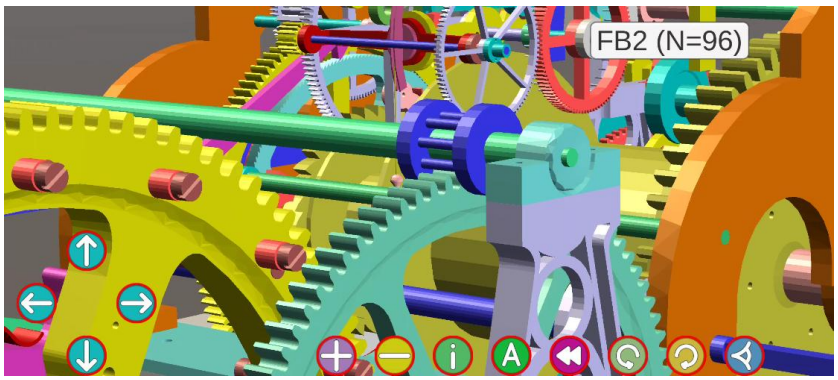

Figure 2: A 3D mobile application for the Notre-Dame clock.

Augmented Reality (AR) is trickier, and although I have had an experiment made with a Microsoft Hololens 2 headset in 2022 (see figure 3), the animations were very slow.

When integrating a model in a 3D scene, it is necessary to distinguish rigid parts, flexible parts and other parts (such as fluids). This may not seem important when using some proprietary software, but it is essential in an open framework. If there are only rigid parts, OBJ files are enough. Otherwise, for flexible parts, either one can use a range of parts, or one can produce the motion of the flexible parts in Unity (or another game engine), using open source code.

[4] `https://unity.com`

[5] See Denis Roegel: *The first 3D clock mobile application*, 2022.

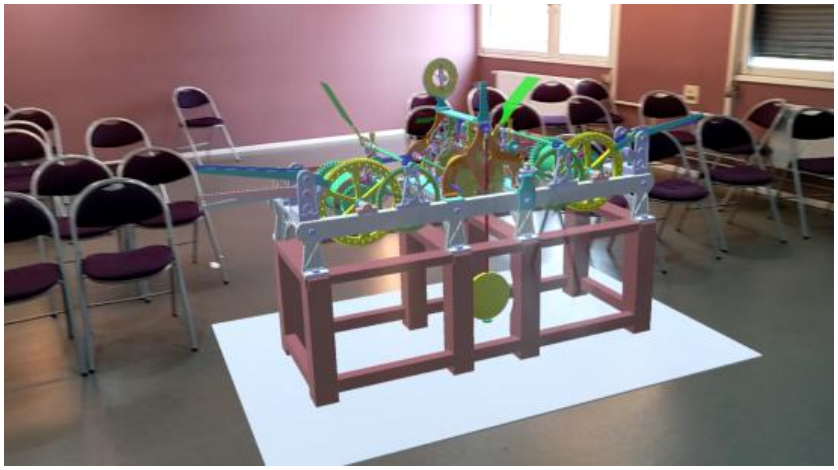

Figure 3: Capture of an interaction on a Microsoft Hololens 2 headset. Here the Notre Dame clock is shown in reduced size within an actual classroom.

The OBJ files can of course be created with any CAD software, and even can be programmed in conventional programming languages such as Java, C, python, etc. It does not matter which software is used, whether SolidWorks, CATIA, Autodesk Inventor, ZWCAD, etc., or free tools such as Blender.[6]

6 The caveats of using 3D models

6.1 Basic rules

There are some basic rules to observe when museums are dealing with 3D models. It is desirable to have 1) a certain openness of models, 2) freedom with respect to models, and 3) flexibility. What is meant here?

Models should be open source and entirely accessible to all, at least as far as the components of the models, their layout, and their operations are concerned. This is like asking for a car that all its components are reachable and that we know precisely how the car works. This should not be kept secret, and the openness will make it possible to construct other experiences based on the same models, within a given museum, or possibly elsewhere, for the benefit of all. This does not mean that the authors of the 3D models should be deprived of their work. They will retain their know-how,

[6] `https://www.blender.org`

but the actual source files (for instance SolidWorks files) should be made available to the museum, and the museum should have all the rights on these files. This is also a fundamental matter of sustainability. What will for instance happen if the author of the 3D model dies? Will the 3D models also vanish? Museums have to think about that and enforce the transfer of property from the authors of the models.

Freedom means that a model should not be tied to a person or to a software, and that its use should be free, without having to go through some filter. And flexibility is in fact what is gained from the first two rules, namely that it must become possible to use a model anywhere, anytime, and with any software.

In summary, it is essential, when setting up a modern virtual technology museum, to ensure that

1. *the models available do not rely on a specific platform or software* (such as CATIA, Creo Parametric, SolidWorks, Autocad Inventor, etc.); a model may have been built with some specific tool, perhaps a proprietary software, but eventually usable components should be made independent of that software and use solutions which are as free and flexible as possible;

2. *a museum (or another structure) does not rely on a specific person*; this is a consequence of the openness requirement; when a model needs to be changed, or perhaps if a model needs to be rendered differently, this should be possible without involving the initial constructor; this is like allowing spare parts in a car to be provided by other companies than the car manufacturer, or allowing a cell phone subscriber to change his/her carrier without having to change his/her phone number;

3. *a museum does not restrict itself to an artificial particular domain* (such as clocks); in other words, a virtual exhibit may have a much larger scope than one may have anticipated; the work I did when modelling the Notre Dame clock can easily be applied to domains which are totally unrelated to clocks; it can for instance be applied to construction building, such as bridges.

The ideas expounded earlier suggest that there should be a database of assemblies, and that all these assemblies could be triggered or loaded through user choices, or as a consequence of spatial motion. Assemblies should moreover be supplemented by scripts (such as Unity scripts) and

other elements which describe how an assembly functions, but also how certain non rigid parts are constructed.

The designer of an actual prototype should of course consider both some real motion in space (the user physically moves in a room, or in several rooms), and the motion of space, that is a situation where the objects move, but the user moves very little.

The great advantage of this view is that it should be possible to import external models, and that it would make the collaboration between various designers quite natural. The task of making 3D models would neither be concentrated in only one person, nor in only one piece of software, nor on some particular domain.

6.2 Museums' fundamental missions and priorities

Even though the use of immersive technologies is very interesting, museums should not entirely go digital, because the heritage they are building upon is made of real artifacts. The world is still full of historical items studied by archaeologists, scientists and historians, and these objects should not be dismissed merely because we now live (mostly) in a digital world.

Actual items still have to be cared about, need to be restored, exhibited, researched, etc. There is therefore also a danger, of which we must be aware, namely that a virtual museum may hinder conservation. It is for instance easy to believe that a digital model replaces a classical (perhaps dry) documentation, but this is not so simple. A digital model does not replace an object, it supplements its documentation. It is, like a photograph, an interpretation of an object. As such, it may not contain all the features of interest, and some features of the original object (if there is such an object) may still require investigations. Keeping this in mind, it is essential, for any museum, to ensure that the fundamental museum tasks are still taken care of. It is for instance essential that museum items are inventoried, that they are documented, that researchers still get a privileged access to the items. If not, the museum will be like a shell resting on dead foundations. *Museums need to foster research.* Unfortunately, some museums, and also some archives, have taken this dangerous path of totally preventing access to the original items, or restricting the work of researchers and even denying their existence. This, in fact, slowly kills research, and we must be aware of it.

There is in fact often a tendancy to think that whatever is possible should be done. Everyone wants to use 3D, VR, etc., but perhaps we should pause, and ask ourselves where these technologies are really nec-

essary, where they add something, and what to do for them not to hinder other priorities. Perhaps museums should rethink their missions, and wonder if one of them is not education. Should entertainment prevail on education? So one may wonder if it is useful to have a VR experience when it is only an entertainment (such as for the Strasbourg astronomical clock). Are these experiences not more interesting or useful for their authors than for the visitors? Who does really benefit from them?

And what is the real audience of VR? For instance, in the case of clocks, I doubt that clockworkers[7] need 3D reconstructions or VR for mechanisms which are rather simple. One should remember that all these objects were constructed without using sophisticated 3D tools, and this means that it is unlikely that 3D is necessary to understand them. In the case of tower clocks, the mechanisms can for instance easily be studied visually. I really believe that photographs and drawings are sufficient for clockworkers. Finally, this also raises the question of how much knowledge should be digested when it is fed to a visitor. Should everything be made simple, or looking simple, or wouldn't it be better if the visitor were subjected to some intellectual (learning) effort?

In the domain of clocks, the real audience of 3D, VR, etc., are the laymen, not the professionals. This obvious observation is important, because VR is sometimes advocated for professions which perhaps do not need it as much as it is claimed. And it seems often advocated for entertainment, but whether an increased knowledge and understanding follows may sometimes be debatable.

7 Conclusion

In this brief note, I have laid down some ideas on a future prototype of virtual technology museum. I hope that some of these ideas will prove useful to those who will undertake the task of making these thoughts come true.

[7] I am using this word intentionally, because there are basically no clockmakers any more, only clockworkers.