Sculpting with SARA (Spatial Augmented Reality Assistance)

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Abstract

We explored how spatial augmented reality can assist sculpting in the physical space based on a digital 3D-model. As a result of our findings we propose a setup of software and hardware as well as methods to use these (SARA), that can visually guide an artist in the work of manual transfer of digital to physical three-dimensional form. As a tool SARA could be used much more loosely; the relationship between a digital 3D sketch and a finished sculpture can conceptually be thought of as similar to a rough underdrawing and a finished oil painting. In this case, the 3d sketch is there as an initial idea and a guide, but not as a ground truth. Beyond the scope of this project, SARA could be further explored in relation to artistic questions. In practical terms, SARA works in the following way: The colors projected during sculpting indicate how much the distance deviates from the digital sketch in relation to the projector. The colors are updated in real-time, as a 3D depth camera is continuously scanning the working space.

Sammanfattning

Vi har undersökt hur rumslig förstärkt verklighet (spatial augmented reality) kan användas som hjälpmedel för att skulptera i det fysiska rummet, utifrån en digital 3D-modell. Vi presenterar mjukvara och hårdvara som visuellt kan vägleda en konstnär i arbetet med manuell överföring av digital till fysisk tredimensionell form, samt metoder för att använda dessa (SARA). Som verktyg kan SARA tillämpas mer fritt; förhållandet mellan en digital 3D-skiss och en färdig skulptur kan konceptuellt betraktas som förhållandet mellan en skiss på duken och den färdiga oljemålningen. 3d-skissen finns där som en första idé och en vägledning, men inte som en absolut sanning. SARA skulle kunna utforskas ytterligare i förhållande till konstnärliga frågor som inte omfattas av detta projekt. Rent praktiskt fungerar SARA på följande sätt: De färger som projiceras anger hur mycket avståndet avviker från den digitala skissen i förhållande till projektorn. Färgerna uppdateras i realtid, eftersom en 3D-kamera kontinuerligt skanner arbetsområdet.
Method

The development of SARA has been based on:

1. **Iterative development of tools and methods**
   Draft and implement the initial prototype, then test and further develop it in several iterations (work cycles) based on outcomes of workshops or labs (test sessions).

2. **Formative user studies**
   Through workshops or labs with invited guest users, generate knowledge about the usability and other aspects of the current version of software and physical setup. This knowledge can then feed the iterative development.
Project timeline

**Phase 1 - Idea and planning**
We wanted to iterate development and testing on real sculpture cases, and the minimal setup was to use one projector and one Kinect 3D camera, this would not be sufficient, but still good as an initial test. After some basic testing it was clear that manual calibration of all the camera parameters was very hard (and perhaps not even possible). If the calibration is off, the experience of the augmentation would always be frustrating for the artist, so we tried to solve this issue next.

**Phase 2 - Software**
Software was created to calibrate and display the 3D in augmented fashion. It is a solution which requires the Unity Game Engine editor in order to operate. The project file, and additional technical information can be found at [https://github.com/teadrinker/projection-assisted-sculpting](https://github.com/teadrinker/projection-assisted-sculpting)

**Phase 3 - Testing**
Together with Henrik Ekesiöö we tried out the initial version on a case where he undertook to make a larger variation of an already existing bust (the original sculpture was first 3D scanned in order to obtain the model).
Phase 4 - Iterated development and Workshop

As we suspected, a single perspective (one projector and camera) was not enough for good practical use, but instead of adding more tech, we went for a basic solution where we could rotate the setup in 45 degree increments. See figures below for the setup, it’s 2 60x60 cm plywood pieces, the top one rotates.

 Except for the rotating plywood piece, the whole setup is glued in place (the box is fixed to the floor, the sculpture is fixed to the rotating plywood piece etc). Holes are drilled for the 45 degree increments. We also added better calibration that could also be reused until you move the cameras.

Workshop

After a few shorter labs and following additions/iterations a workshop was carried out as a part of the course *Mimicking Configurations* at KKH (Royal Institute of Art). During two days Martin Christensen and Henrik Ekesiöö guided 8 fine art students in creating physical form from 3d models on two setups of SARA. During this work the setup was really stress tested and resulted in more adjustments and suggestions for future refinements.
Results and Conclusions

When a sculpture is to be made based on a digital original (3d scanned physical object or created in a computer environment) most participants reported they can see benefits in using SARA. Especially compared to other alternatives like large scale 3d milling, which is comparatively very expensive and also excludes the artists influence during the process.

Also, participants generally seem to enjoy using the setup, it makes them feel a bit more relaxed when working on the course-basic form and then focus their energy on the finer details.

While SARA is easy to use once calibrated, it requires some familiarity with Unity to set it up. However, there are a number of ways the automatic calibration can fail, such as banding in the Kinect RGB camera (due to the projector not being able to draw a complete frame when the Kinect RGB camera shutter is open), or that the relationship between the projector and Kinect resolutions cause coded light to fail. In these cases it might be hard even for a fairly technical user to solve the issue.

Ideally, the sculpting work area and cameras are set up, calibrated and fixed in place. Basic features, like rotation and resizing the 3D file, changing the lighting of the virtual scene, turning augmentation on/off etc, should all be accessible from a physical control panel at the sculpting work area. This means that all the artist has to do on the actual computer is to load their 3D model. A simple way to achieve this would be to just have a wireless/long wired keyboard next to the work area with keys relabelled.

While this KFoU project has focused on a more technology and usability centered exploration and development of SARA, we believe it could be further explored in relation to artistic questions. But that lies beyond the scope of this project.

Thanks to

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