INTERACTIVE 3D MODELS FROM PHOTOS

REPORT ON THE PHOTOGRAMMETRY AND UNITY WORKSHOP IN HELSINKI, IN 2015, WITHIN THE RESEARCH OF "ARCHITECTURAL DEMOCRACY"

By Pedro Aibéo
[M.Sc. Architect M.Sc. Civil Engineer, PhD.c. Architectural Democracy, School of Civil Engineering, Aalto University, Helsinki]; 25.01.2015

Keywords— architectural democracy ; photogrammetry; unity; workshop
#ArchitecturalDemocracy : http://architecturaldemocracy.com/

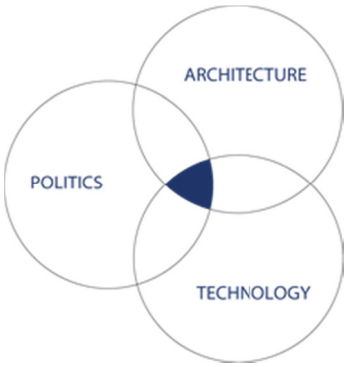
With the kind support of Aalto Service Factory

Contents

Introduction

With the support of the ASF (Aalto Service Factory[1]), several international researchers were invited to Helsinki within the Electricity Festival and the Helsinki Design Week. This report describes the process and content of the Workshop on "*Interactive 3D models from Photos*" which took place from 26th till 27th November 2015. The event was organized by Pedro Aibéo and framed around his doctoral research of "Architectural Democracy".

About Architectural Democracy



"Architectural Democracy" (AD) deals with the relationships between architecture, technology and politics and its repercussions for citizenship, architectural practice and policy making. It is concerned with ways of using technology to turn buildings into open source interfaces, to improve the public understanding of the built environment for the everyday life of citizens, and with it, the quality of political participation. It focuses on buildings, in cities, due to its human scale and cross-generational properties. The approach is done through research[2], industry and interventions. To date, practical tools have been developed for citizens, for the real-time public access and edition of building's metadata: a combination of smartphones, open source BIM (Building Information Modeling), and photogrammetry.

Background and preparations

Photogrammetry trials in Porto, Portugal

In 2014, Pedro Aibéo contacted Mr. Hugo Pires, an experienced photogrammetrist with groundbreaking work on MRM (Morphological residual Modelling (Pires et al., 2014)). After getting to know his work through his published articles at National Geographic Magazine, Mr. Aibéo invited Mr. Pires to make a series of tests in creating 3D models of buildings from photos, in a low budget format.

Fig. 1. First photogrammetry tests performed in Porto, Portugal in 2014. The building on the left was successfully striped out of its façade. The video: https://www.youtube.com/watch?v=6NDiOEX4LgA

Along the lines of the research of AD, it is fundamental to build up prototypes to test the implications of "editable" buildings. This cannot solely be done via the ongoing policies of BIM for the new public buildings, but, and most importantly, it must be tested through a truly decentralized system. The

[1] funding granted to Pedro Aibéo in 2013

[2] Doctoral research of Pedro Aibéo based at Aalto Doctoral Programme in Engineering, Major: Building Technology. Supervisors: Prof. Vishal Singh, Mari Åman, Prof. Heikki Remes. Advisors: Prof. Jukka Nurminen. Currently funded by Kone Foundation.

success of the first trials at Caldeireiros street in Oporto, lead to several and fruitful interactions with Mr. Pires, both at practical and at a research level.

During the same year, Mr. Aibéo invited Mr. Pires to perform a series of tests, meetings and talks in Helsinki, sponsored too by the ASF funding. Among the institutions involved were the Photogrammetry Institute of Aalto University and the Mannerheim Museum. The results of it created further collaborations and needs. Among those was the need to continue the process of DIY 3D models into an interactive one, similar to a BIM model with its metadata, but avoiding the software sophistication and centralization that this one requires and the consequential software proprietary concerns.

Interaction trials

In 2015 Pedro Aibéo invited Prof. Rolf Kruse, an experienced Interaction Designer based at Erfurt University of Applied Sciences, and who has been collaborating with Mr. Aibéo in several other projects in the past[3], to add interaction to one of the point cloud model produced by Mr. Pires. The successful trials were done on the Marmori Palatsi model.

Fig. 2. Photogrammetry tests performed in Helsinki included the Marmori Palatsi which was later incorporated into unity 5

The next step was to increase the processing speed and robustness of such a process. For this, and during the same year, Mr. Aibéo contacted Prof. Gabriel Falcão from the University of Coimbra, Portugal, whose Institute had just received a Google Faculty Research Award from Google Inc. for its algorithmic breakthrough on 3D reconstruction from stereo image processing (Ralha, 2015) in using parallel processors of the GPU type (Falcao, 2012). This had the potential to ease up the whole pipeline of the 3D modelling into a more local, less energy intensive one. In the last years Prof. Falcão's work has focused on the development of energy-efficient accelerators for real-time image processing based applications in the areas of error-correcting codes, medical imaging and 3D reconstruction of urban environments. After some online talks, Mr. Aibéo concluded that it would be more beneficial to invite all three experts involved (Pires, Kruse and Falcão) to meet in person and to discuss and test potential pathways. To do so, Mr. Aibéo organized a workshop open to the public, which would serve several other purposes alongside: it would involve the local community and other experts and would build up a discussion platform among experts and lay people, a fundamental and most needed equation in any research.

[3] It includes Fraunhofer Institute, European Space Agency and State Theater Darmstadt

Preparations

For that effect Mr. Aibéo used the ASF Fund still remaining from 2013 and allied itself to the Electricity Festival organized by *LeSPACE*[4] and as an event by the renowned *Helsinki Design Week*[5]. The workshop involved a fee for non-Aalto students to cover extra costs related to food during the workshop.

Prior to the event, a new website[6], a joint scheduling tool[7] and advertising through printed flyers and posters was done and a total of 17 people attended the 2 day workshop along with several other Professors and Professionals who came over to meet the experts. The current direct link to the workshop: http://www.aibeo.com/#!workshops/cvz7

Fig. 3. Workshop's flyer and poster. Prof. Falcão was firstly publicized only for internal meetings.

The Workshop

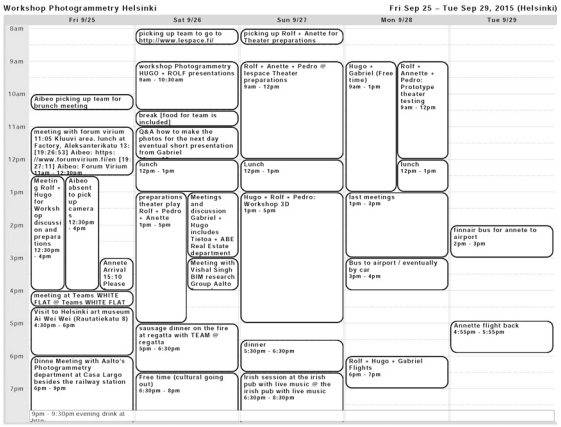


Fig. 4. The briefing included information of the persons and institutions to meet.

Arrival

Upon arrival, the guests were taken to their accommodations and were handed a schedule draft, flyers and a briefing on the upcoming meetings and on the workshop.

Content

The workshop was advertised on the web with the following explanation text (also in Finnish): *"Learn how to make an interactive 3D model of the rooms of your house with your own photo camera. A hands-on, two day workshop, with experts from Germany, Portugal and Finland, in a relaxed environment. On a two day workshop at LeSPACE, we invite everyone above the age of 8 to learn how to take photos of their home and turn them into an interactive 3D model. These new 3D models will be placed online, in an online map, so you can share them with your friends. They will allow interaction with the 3D objects you created. Bring your own laptop with wi-fi connection and a camera (also mobile phone camera possible). Participants should know how to use a computer and take photos! This workshop is part of the international research on "Architectural Democracy" based at Aalto University. Our team believes we can use the rooms where we spend most of our lives, as sources of open source information to edit and share among citizens for community well-being. Not only is this a tool to create time machines to understand the history of our cities but to understand its economics, technicalities and social relationships, for a fairer society based on transparency. The course is held mainly in English but Finnish is also available. Please contact us in English."*

[4] http://www.lespace.fi/index.php?page=productions
[5] 2015's theme of the design week was the "Time Machine": focused on cities and their future. ttp://www.helsinkidesignweek.com/?lang=en
[6] http://architecturaldemocracy.com/
[7] https://www.smartsheet.com/

Everyone above the age of 8 and both experts as well as amateurs was welcomed. The target group was software developers, designers, urban innovators, game designers and architects. Also, to save valuable time, the participants who subscribed to the event were adverted to install the following software on their computer in advance and to bring both laptop and smartphone along:

- Unity 5.1 Personal Edition
- Autodesk 3ds Max 2016 30-day-Trial
- 123D Catch
- Visual SFM
- Meshlab

Fig. 5. First moments of the workshop

The workshop initiated with an introduction from Mr. Aibéo explaining the schedule and introducing the speakers: *"We'll use the first session to introduce 3d scanning concepts and for tackling issues concerning photo capture. Between the two sessions each one makes his own photo capture (at home, work, street). In session 2 we'll build models from the photos each one took using on-line processing (123D Catch) and learn how to edit them in a 3D editor (MeshLab). During the two sessions we'll use Visual SFM to explain how the photogrammetric engine works because with 123D catch you don't see anything of what's going on. By the end of workshop, participants will know how to build simple 3d models from photos and how to edit them. As a final task, the models can be uploaded in sketchfab and be available for everyone."*

On the first day, there was an introduction to photogrammetry and on interaction (framed around unity) followed by software installation and work assignments. The second day was more focused on helping the participants with their difficulties and questions:

Saturday 9:00 – 12:30
Welcoming by Pedro Aibéo
Introduction to photogrammetry and tools (Mr. Pires)
Hands-On with photo shooting (Mr. Pires)
Introduction to interactive scene creation (Prof. Kruse)
Software Installation
Home task for participants:
    Photo shooting of one or two (connected) rooms
    Upload photos to Autodesk 123D Catch
    Download generated 3D-Model
    Import and optimize data in Meshlab

Sunday 14:00 – 17:00

Prof. Falcão presentation & discussion
Check generated 3D-Data (Mr. Pires)
Step-by-step walkthrough for creating interactive scene (Prof. Kruse)

Mr Pires' Presentation

Mr. Pires is a photogrammetrist with vast field experience in geomatics. He has developed the technology of MRM (Morphological Residual Modelling) where formerly untraceable archeological remains are now readable. Such groundbreaking approach has deepened his involvement into academics where he is now mostly active. He is an invited author of the National Geographic Magazine and some of his articles include the "*Morphological Residual Model. A Tool For Enhancing Epigraphic Readings Of Highly Erosioned Surfaces*" or the "*From point clouds to archaeological evidence: Improving visualization and spatial analysis of 3D data*"[8]

Mr. Pires' presentation introduced firstly the joint work done with Pedro Aibéo in Porto which explained the principle of parallaxe, a fundamental one to photogrammetry. It followed the tests done in Helsinki in 2014 at the Marmori Palatsi, Viipurinkatu, the Arabia Campus and Mannerheim Museum. At Marmori the low lighting conditions and the homogeny surfaces (with low contrast) of the indoors were rather challenging to create a good 3D model. At Viipurinkatu, Mr. Pires showed the embedding of the newly created 3D models of a residential building into an online map. At the end of the presentation Mr. Pires introduced the free software[9] to be used during the workshop and facilitated its installation among the participants.

Fig. 6. Mr. Pires' presentation at LeSPACE in Helsinki 2015

Fig. 7. Mr Pires supporting the participants which were of very different ages and backgrounds

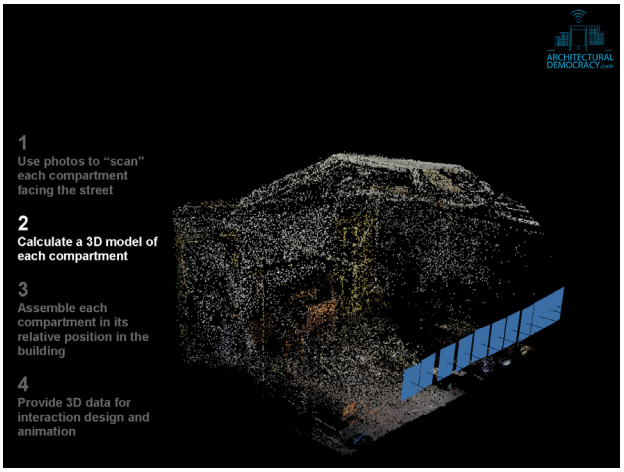


Fig. 8. Mr. Pires' presentation included the process of generation of 3D models from photos based on paralaxe

[8] Further publications can be read here: https://independent.academia.edu/hugopires
[9] mainly being 123Dcatch and Visual SFM

Prof Kruse's presentation

Prof. Kruse currently teaches Interactive Media Design at the Erfurt University of Applied Sciences (FHE). He has an extensive practical experience with Institutions such as the European Space Agency or the Fraunhofer Institute. He has been doing much work around virtual reality including the development of a low budget virtual reality system for a theater play at the Darmstadt's State Theater which was later acquired by Siemens AG. This theater play was the first interaction with Prof. Kruse and Mr. Aibéo, back in 2007. His background in Architecture (Dipl. Ing.) and his flexibility in finding low key solutions for complex problems are fundamental for this joint work.

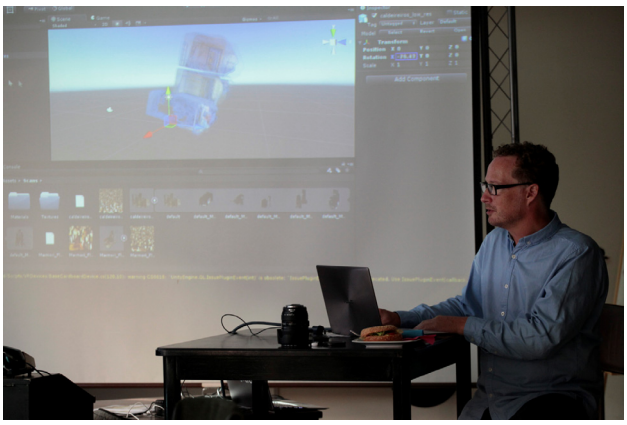


Fig. 9. Prof. Kruse's presentation

Prof. Kruse presentation focused on the usage of unity 5. Picking up the first example of Mr. Pires, the house of caldeireiros in Porto, he showed how to incorporate the point cloud model into unity 5 and then how to build up physical elements into it.[10]

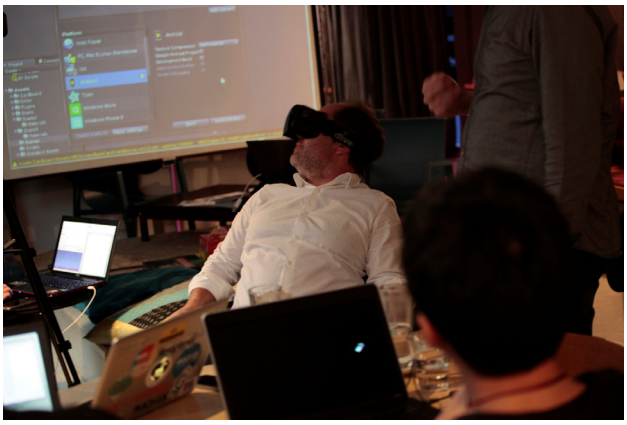


Fig. 10. Prof. Falcão being guided by Prof. Kruse through a VR tour inside of one building at Porto.

Software requirements were Unity 4.6 (free) or newer. At the workshop one used the version 5.2 Personal Edition (or Pro) on Windows with the additionally standard assets. No advanced features which involved programming (in C#) were needed during this workshop.

Fig. 11. Prof. Kruse clearing out technical doubts among the participants

Prof. Falcão's presentation

Prof. Gabriel Falcao carries out his research activity at Instituto de Telecomunicações and Department of Electrical and Computer Engineering, Faculty of Science and Technology of the University of Coimbra (FCTUC), Portugal. He currently investigates efficient parallelization techniques, algorithms and architectures for compute-intensive signal processing applications (Ralha, 2015), as well as novel paradigms (Pratas, 2013) for achieving energy-efficient fast parallel computation (Falcao 2012, Owaida, 2015).

Entitled "GPUs and parallel computing, towards 3D reconstruction", Prof. Falcão presentation was divided into three parts:

[10] the procedure can be found at attachment 1 - Interactive Scene step by step by Prof. Kruse

- The evolution of CPUs (from single to multi-core)

- GPUs (Graphics Processing Units), a hardware designed for high parallel applications and which had a tremendous boost over the last years, mainly via the gaming industry.

- Real-time 3D reconstruction based photo-symmetry (SymStereo - Dense)

The buildup was necessary to understand the importance of parallel computing in order to create a real-time pipeline that generates realistic 3D volumes. The new algorithm generates 3D models automatically by recognizing geometries (plans) which are stored in a very compact form (as opposed to existing methods that are based on compute- and bandwidth-intensive point cloud systems), allowing rapid data transmission and volume construction (potential for 3D reconstruction in real-time has been identified). Furthermore, this approach has proven to be able to work with only a small number of images. The acquisition of pairs of images can be performed using conventional stereo cameras (< 300€) but it is also possible to use regular cameras (previously calibrated).[11]

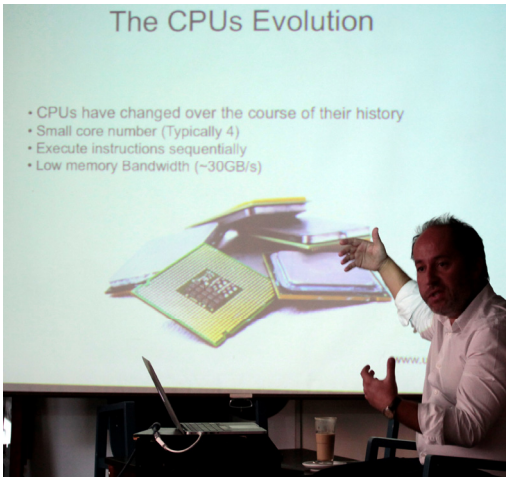


Fig. 12. Prof. Falcão starting his presentation

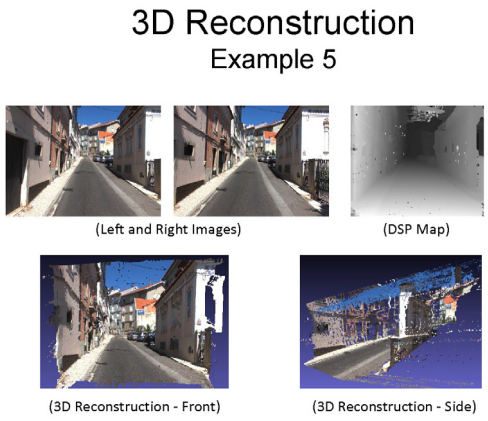


Fig. 13. Prof. Falcão's last slide with many examples on their 3D generative process

The Meetings

During and around the workshop, the invited speakers met several experts in Helsinki:

Meeting with Forum Virium

The first day, the 25th, was reserved solely to meetings. The first one was set at 10:00 am at the "Factory" cafeteria in downtown Helsinki at Aleksanterikatu 13 with Hugo Goncalves (hugo.goncalves@forumvirium.fi) and Roope Ritvos (roope.ritvos@forumvirium.fi) from Forum Virium.

Forum Virium Helsinki is an innovation unit within the Helsinki City Group. It develops new digital services and urban innovations in cooperation with companies, the City of Helsinki, other public sector organizations, and Helsinki residents. The aim is to create better services and new business, plus to open up contacts for international markets.[12]

There has had been former meetings with Mr. Aibéo and Forum Virium. They have shown great interest in the ideas and Modus operandi of "Architectural democracy" but despite many promises of

[11] Pointers to some of these results of this lab can be seen here: https://developer.nvidia.com/academia/centers/university-coimbra
http://home.isr.uc.pt/~jpbar/Videos/eccv2014.mp4
http://home.isr.uc.pt/~jpbar/Publication_Source/eccv2014.pdf
https://youtu.be/KrF8rsXuNOk
[12] Retrieved from http://www.forumvirium.fi/en

collaboration, mainly through joint H2020 applications, all of these have fallen into oblivion. The main areas of interest of Forum Virium were on the side of energy conservation and the revitalization of public spaces.

Meeting with Aalto's BIM Initiative and Prof. Singh

The BIM initiative seeks to directly engage in problem discovery and solution design with leading developers and adopters of BIM.[13] The brief meeting with Prof. Singh and the invited researchers was held at LeSpace during the workshop.

Prof. Singh was key to enable this workshop through his letters of invitation to both the University of Coimbra and University of Erfurt (see attachments). As supervisor of Mr. Aibéo's doctoral research the meeting had the function of getting to know each other's work and to establish a working plan. From the meeting it was clear that future collaborations will continue to take place in both practical and academic level.

Meeting with Aija Staffans (ABE) and Liisa Horelli

Aija Staffans is a Senior Researcher Fellow at YTK and has been developing ABE (Aalto Built Environment Laboratory), a cross-disciplinary research facility with an interactive modelling and visualization space at Aalto University.[14]

Dr. Liisa Horelli is an Adjunct Professor and environmental psychologist who conducts research at Aalto University, on participatory e-planning and smart cities.[15]

Both Aija and Liisa have been following Mr. Aibéo's work and several common projects have come to fruition such as the 2015's 3D City Model Hackathon. There is a common understanding of the importance of a Human-centric living environment on the whole smart cites strategy. From the meeting it was realized that possible cooperation around the Otaniemi campus development is desirable.

Meeting with Tietoa's Project Manager Jaakko Hauru

Tietoa is a Finnish company offering BIM- and visualisation services for building owners and developers, constructors, construction professionals and designers. "Tietoa" is a Finnish word for information and knowledge – the core of modern virtual building.[16]

Fig. 14. Prof. Falcão with Jaakko Hauru

[13] Cf. https://wiki.aalto.fi/display/ABIM/Aalto+BIM+Initiative+Home
[14] Retrieved from http://maa.aalto.fi/en/research/ytk/research/abe-2/
[15] Cf. https://wiki.aalto.fi/display/Palco/Liisa+Horelli
[16] Cf. http://www.tietoa.fi/

Jaakko Hauru is a project manager at Tietoa and has been collaborating with Mr. Aibéo since the 2015's presentation at Senaatti. (http://www.senaatti.fi/en). After conversations with Prof. Falcão and Mr. Aibéo, a short-term project was agreed, and currently Mr. Hauru and Mr. Aibéo are scanning the city of Helsinki with a new developed low budget stereo camera, in which Prof. Falcão is processing the data and turning it into 3D.

Meeting with the Photogrammetry research Group of Aalto

Fig. 15. Meeting at Istava Café, downtown Helsinki (Photo by Hugo Pires)

Representing the research group of Photogrammetry and Remote Sensing based at the department of Real Estate, Planning and Geoinformatics, was Petri Rönnholm and Lehtola Ville, who met all the invited researchers at Iltava in downtown of Helsinki. In 2014, Petri Ronnholm conducted a short experiment on the usage of photogrammetry free software among his students for the course of "ENY-C2005 Geoinformation in Environmental Modeling: Photogrammetric 3D modeling of indoors" with the support of Mr. Aibéo and Mr. Pires. (attachment 2: course description). The results of it were inconclusive. On the meeting of 2015, the research group showed special interest on the work of Prof. Falcão and on his new developed algorithm. No further plans were set.

Internal Meetings

In several occasions either in groups or all together, the researchers discussed with Mr. Aibéo pending and future projects. Among these:

Collaboration with 3Decide:

3Decide is a software company in Portugal, which has experimented with the idea of panorama photos around the caldeireiros building in Porto. Online version here: http://3decide.com/showcases/interactive-3d-workshop/

3Decide uses aLIVE Vision, a Visual Information System that fuses user generated content (GPS Coords, 3D Models, 2D Drawings, 360º Photos, ...) into ready to use interactive visual experiences solving major issues like easy sharing, information update, collaborative workflows, cross platform compatibility, etc.

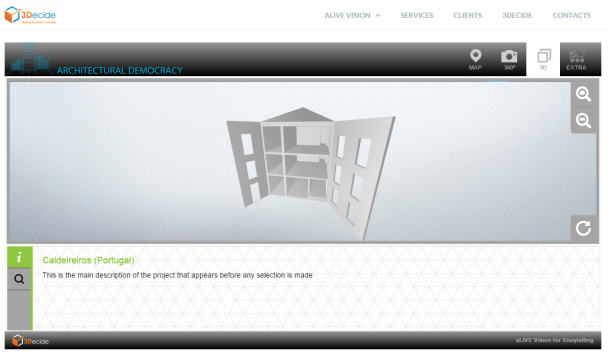


Fig. 16. Snapshot of the trial. The 3D model of caldeireiros

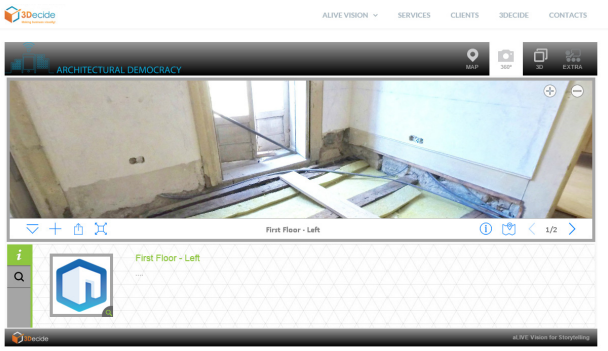


Fig. 17. Snapshot of the trial. Part of the panorama of caldeireiros

The visual contents are stored in universal / open standards and can be created with an increasing number of SWs / HWs...The aim is to democratize the creation of immersive and meaningful visual experiences with a "Tell your story" attitude rather than just "dumping" multimedia content, facilitating deeper collaboration among specialties (3D, 2D, Photo, Copy Writing, Story Telling, ...), even remotely.

The collaboration with UNAM Mexico and Wuhan Universities:

Both Universities have been inviting Mr. Aibéo to teach around the topics of Architectural Democracy and to help their Departments developing further its Master and Doctoral programs. Ongoing are the possibility of repeating the same 3D workshop of buildings at their campuses by students.

Possible cooperation with REACT

A project of the MoBiVAP group (http://www.mobivap.eu/). They have been developing strong work on CityGML with a LoD of 4.

Other discussions involved the continuation of the interactive façade idea for “Casa da Musica”, discussion on the Meetings in Brussels on “Innovating Cities with Nature and Culture” which gathered a great amount of people (mainly lobbyists) to promote contacts and build consortiums around city regeneration through heritage and innovation (an overbooked event!) and others.

Other activities

Along these days Mr. Aibéo organized informal events either for dinning or to visit exhibitions. Included in these was the opening of the Ai Wei Wei exhibition at HAM and grilling at Regatta Café. During these moments, the researchers got to know themselves much better and conjured good ideas to further the cooperation which are ongoing. One of such is the ongoing proposal for the “Casa da Musica”.

Conclusion

The workshop brought together several experts for the first time. The interaction amongst them and with others, either for meetings or during the workshop proved to be again a great working model. These are people passionate about their work who both feel the need to improve every detail of it and to disseminate it to others.

Efforts will be done to repeat such workshops on the same model or in the formats of hackathons.

Acknowledgments

Mr. Aibéo would like to thank Rolf Kruse, Gabriel Falcao and Hugo Pires for their extraordinary commitment and friendship and Prof. Singh for his support and patience.

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All Photos by Pedro Aibéo unless when stated otherwise

Pedro Aibéo
25.01.2015
www.architecturaldemocracy.com
contact@architecturaldemocracy.com

Interactive Scene, step by step
by Prof. Kruse
September 2015

Open Unity and create a new 3D-Project

Create 3 folders in Project: “Scenes”, “Scans”, “Scripts”

Import Models: Drag one .obj plus the according .mtl- and .jpg-file simultaneously from windows explorer onto the “Scans”-folder in Unity …this will take some time because Unity splits he geometry into smaller pieces

In the Hierarchy tab: Create a Container Object and rename it to “Room” (or “Building” or something meaningful to you)

In the Project tab: Find the material(s) in the Materials-folder of your Scans-folder: For each material set the Shader to “Unlit/Texture” in the Inspector. The scanned room should now have a brighter appearance, that does not change if you alter the directional light in your scene.

optional: Disable or remove the Directional Light in theHierarchy

Add all your imported Prefabs (box icon in Scans-folder) to the scene by dragging them on the “Room”-object in the Hierarchy-tab

Optional: Move all objects to the world center by setting the Position of each object in the Transform-component to the same desired values.

Rotate each object facing upwards by setting the “X”-axis of the “Transform” to “270”

Add a default cube as reference with GameObject > 3D Object > Cube. Its default size is 1 x 1 x 1m. If your scanned scene has not the correct dimensions, resize it with the Scale tool. Click on the center of the scaling gizmo and drag to preserve proportions.

Create planes to “walk” on

Switch to Top View, disable Perspective.

Select GameObject > 3D Object > Plane.

Move the created plane in Y-direction to match the scanned ground floor.

Scale it as large as you want the user to be able to walk.

In the Inspector, disable the Mesh Renderer to make the plane invisible.

Add more planes for other floors, if you have such.

Create collision geometry to avoid walking through walls and objects

Create an empty container object and rename it to “Collision”.

Select GameObject > 3D Object > Cube to create a cube object .

Drag it into the “Collision”-container, if it’s not already in there.

Move and size the cube to fit a scanned wall or furniture.

In the Inspector, disable the Mesh Renderer to make the cube invisible.

Repeat this for all scanned objects, which you don’t want the user to walk through.

Finally add 4 invisible cubes as fence along the edges of your ground plane.

Add FirstPerson View

Add some Standard Assets to the project: Select Project > Import Package > Characters. Repeat that for the Utility- and CrossPlatformInput-asset.
If these packages are missing in the menu, download the Standard Assets-Package from the Unity-Website: Select your PLATFORM and then select „StandardAssets“ from ADDITIONAL DOWNLOADS. Install the downloaded package and restart Unity.

Drag the “RigidBodyFPSController”-Prefab to theHierarchy and rename it to “Player”

In the Scene view place it where you want the user to start his/her tour.

Test by pressing the blue Play-button

You should now be able to walk around the scene using the arrow keys and mouse.

Attachment 1: Interactive scene step by step by Prof. Kruse

A Xbox game controller could also be used for navigation.

optional: Viewpoints

Download Spawner.zip, extract and import the Spawner.cs-Script into the Scripts-folder in the Project tab.

Create one empty object as container and rename it to Viewpoints.

Attach the script by dragging it onto the Viewpoints-object .

Add three empty objects into Viewpoints and give them a descriptive name.

Position them at a location you want the user to be placed to.

Select the Viewpoints-object and drag its three subobjects to the according slots in the Inspector.

You now can „teleport“ to those locations by clicking keys „1“, „2“ or „3“…or buttons on the gamepad.

Export as standalone programm (Executable)

Click in File > Build Settings… and check if the selectedPlatform is „PC, Max & Linux Standalone“. If not, then select this option and click on Switch Platform.

Add your scene by clicking on Add Current.

After clicking on Build and Run, you will be asked for a file name.

Unity compiles the scene into a runtime executable and will start it.
This executable (.exe) plus a directory (with the same name plus „_data“) can be used to view the scene without having Unity installed.

If yout want to export to other platforms (Android, iOS, …) several preparations may have to be executed. Please have a look at the according Unity website.

Attachment 2: course description

ENY-C2005 Geoinformation in Environmental Modeling

Exercise: Photogrammetric 3D modeling of indoors

Background: This exercise is integrated in the international project (Architectural Democracy), in which the user-grade methods to use digital images for automatic 3D reconstruction is researched. None of the results (final 3D models) will be published, but we mainly collect user experiences.

Description of the exercise:

This exercise includes individual parts and a group part. As an output each student returns a report and 3D model to the Moodle. Estimates workload is 5 hours.

Individual part 1:

- Step 1. Select a room that you'll model in 3D. This can be any room and the final result will only be seen by you group members and staff. The room can be from your home or any public space in which you have permission to take photographs.
- Step 2. Take many images from different location of the room. Leave one wall without photographs (the wall in which windows are – if there are any). Notice that the quality of images and locations of cameras might be critical for the final results. In addition, occlusions prevent 3D measurements. If you have a systems camera, you might want to read further information to understand your camera and how to modify the image shooting parameters. The basic information can be found in Appendix 1. However, you can take images also with, e.g., the camera of your mobile phone, in which case there is usually not many possibilities to make manual adjustment of photo shooting. In any case, describe accurately how you took images (settings, camera type, sensor size, lens type, which principles you followed during the image acquisition etc.). Remember that photogrammetric measurements require overlap between images. I addition, take many images from various positions.
- Step 3. Use on-line service Autodesk 123D Catch (might require installation of client program and registration or Facebook account) to create automatically a 3D model from images. Don't get upset if the result is not as good as you wanted.
- Step 4. Set the scale of your model. Firstly, create two reference points in your model and then set the distance between them (you have to measure that distance in "real life" with, e.g., measuring tape). In order to be able to measure reference points, you have to click one of the images (image icons are in the bottom of application window). Software automatically suggests the correct location in other images. However, click also other images and correct if the reference point location is not correct one. You may also "clean your model", if there are some parts that are obviously wrong. Just select unnecessary areas and delete them.
- Step 5. Save your 3D model as .obj and return it to Moodle.

Attachment 2: course description

- Step 6. Write down in your report how you managed so far and did you get such results as you wanted

Group part:

- Step 7. Arrange a meeting with your group. Show your model to your group members and discuss about your experiences. Select the best 3D model among your group. Collect all your observations into one common statement. Answer, e.g., to following questions: what was successful/unsuccessful, did you managed to take such photographs that you wanted, were those images optimal for 3D model creation, how you'd like to improve the process, etc. If some part was not as successful as you wanted, try also to give reasons what happened. Write everything as a single text and distribute it among all group members. Each student includes this part in his/her report

Individual part 2:

- Step 8. Answer to following questions:
    - Was this process easy enough for anyone to make 3D models?
    - Was your 3D model good enough to be distributed through some Internet server?
    - If there existed an open access database for 3D indoor models, would you like to share (e.g. your room) 3D models there?
    - Would you model public indoor spaces into an open access database without any profit, if there was a system that makes it possible?
    - Would you make 3D models if someone is willing to pay for them? How much money you'd like to get before start making and distributing 3D models?
    - Would you be interested to use an application in which you could see shared 3D indoor models? In which purposes you'd like to use such application?
    - Can you figure out any interactive tools or features that could be nice for this kind of application?
- Step 9. Give additional feedback about this exercise and estimate how much time you needed to complete it. Return your report to Moodle.

Deadline of the exercise is 23.1.2015.