

# 3D Printing Objects as Installation Art: “Standing Humanity: 3D Yan Character”

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## ABSTRACT

3D printing technologies have been known for several decades and have been already used in arts, most often as accessories rather than as core material of a tangible installation art. We describe “Standing Humanity: 3D Yan Character” a collaborative and participative installation art based on 3D printing objects and we are analyzing participants’ engagement and the playability of the installation. We analyze different types of interaction and conclude that 3D printing objects have a high potential to engage curiosity and open to interactions between visitors and the objects themselves. We finally suggest further investigations to explore 3D printing within the context of collaborative and interactive installation.

## CCS CONCEPTS

• **Applied Computer** → **Arts and humanities** → Performing arts

## KEYWORDS

Installation Art, 3D Printing, Interaction, Participation, Practice-based Research

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## 1 INTRODUCTION

For the last 40 years, since its creation, the additive manufacturing industry has improved technologies, lower costs and continuously reached new limits in quality for the physical representation of 3d computational models. However, these technologies have remained expensive and hard to access for artists and researchers.

The end of some fundamental patents in 2009<sup>1</sup>, has opened doors for a competitive market in the last decade. We have seen a lot of technological innovations, prices have also dropped exponentially and, as importantly, some very active and innovative open-source projects such as the RepRap [1] project have emerged and have started to gain popularity, even in young generation and school environment [2, 3].

3D printing technologies are nowadays more and more used for installation art around the world providing a unique technology to create complex physical objects otherwise almost impossible to realize or at least extremely difficult (not to mention costly as well).

It is a new source of inspiration for artists, allowing them to materialize their ideas and embody their concepts in new creative ways as well as new materials and shapes. An example of such creation can be seen in the installation “Next Industrial Revolution”<sup>2</sup> by artist Gilles Azzaro or the project from Xuedi Chen and Pedro Oliveira “X.Pose”<sup>3</sup>.

It is also opening new experimentation in exploring research and educational concepts by physically representing them in tangible objects, such as mathematician Henry Segerman [7].

In this paper, we are interested in investigating 2 related topics: 1) to experiment the potential playability of 3D printing objects in a participative installation art [4, 5]; and 2) to propose an experiment to study the potential, possibilities but also limitations of consumer-grade 3d printing technologies within the context of exhibitions open to the public [6].

<sup>1</sup> S. Scott Crump. 1992. Apparatus and method for creating three-dimensional objects: <https://www.google.com/patents/US5121329>

<sup>2</sup> <http://www.gillesazzaro.com/pages/en/printing3D.htm>

<sup>3</sup> <http://xc-xd.com/#/xpose/>

In that sense, we propose to describe and analyze the participative installation art “Standing Humanity: 3D Yan Character”. Our conclusions, recommendations and the implications of our initial experiment for the future are then discussed.

## 2 CONTEXTUALISATION

From December 15th to December 30th of 2016, we setup a participative installation art where we 3d printed a two-meter-high Chinese character ‘人’. The public was invited, over the exhibition period, to see the full process of construction including the printing, assembling and gluing. Participants were as well encouraged in social interactions with the artists and participate in several areas of the installation.

The Chinese character ‘人’ (pronounced “Rén” in Mandarin, “Yan” in Cantonese) was chosen for the following reasons: 1) its meaning in English is ‘people’ or ‘human being’; 2) the shape of this character (the same in Mandarin and Cantonese) looks like a person standing and walking forward, 3) Technically, the character is a simple shape compare to other characters and it can easily be identified and remembered for non-Chinese public, finally, 4) the shape will allow the built character to stand on its own, without the need of any extraneous support.

The exhibition manifesto we developed in a short booklet available to the public was the following: “Technologies have a tremendous impact in our daily life, they have become fashionable, desirable and somehow they define us, they shape us and they are giving us a social status. They are transforming our bodies and our life to make us better humans or simply to keep us from our own evil side. But, as everything humankind is creating, technologies are also an extension of ourselves, a projection of our thoughts and feelings. A deep outreach to our social peers, a need from our soul to engage in relationships. To



Figure 1: 3D Chinese character completed (left) and with spatial augmented reality projection (right). Photos taken on December 30<sup>th</sup> of 2016.

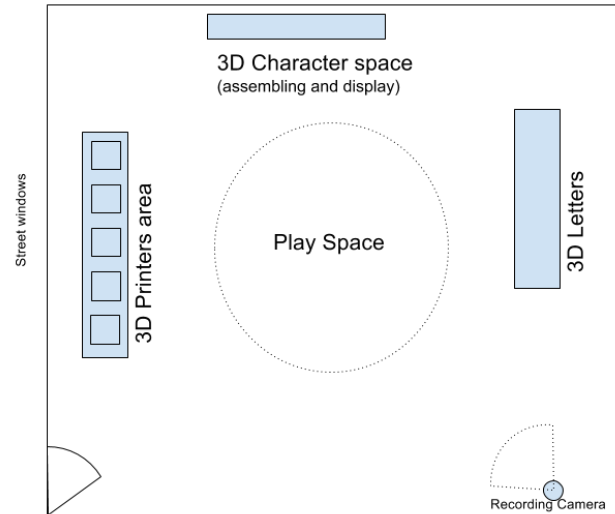


Figure 2: The installation setting including four main areas: 3d printers, 3d letters, Character exhibition and finally the play area for the participants.

reach the sky. To touch the infinite.”

The Chinese character symbolically represents the humanity and each individual and unique block composing it, represent individual and unique human being.

## 3 INSTALLATION

The installation started without the Chinese character, whom was printed over a course of 7 open days, from December 15<sup>th</sup> to December 28<sup>th</sup>, due to numerous local public holidays in this period of the year. We included as well other participative 3d printed system to encourage and stimulate the public participation as described in the next sections.

### 3.1 Exhibition Space

This installation art was created for the Creative Macau – Centre for Creative Industries<sup>4</sup> space where they offered us a reserved area to propose a new genre of 3d printing experience based on the original concept described earlier.

We designed the setting of the allocated space with several dedicated areas discussed below, as well as a large area on the middle created to invite participants to interact, play and participate as shown in the Figure 2 below.

A visual installation was created to integrate five printers in the overall installation. The printers were visible from the street

<sup>4</sup> <https://www.facebook.com/CREATIVEMACAU/>

to encourage people to stop, watch them and eventually enter in the exhibition space.

Over the course of the exhibition period, participants could see all steps of the creation of the Chinese character as well as participate in activities related to 3d printing technologies and described below. Due to the live creation during the exhibition period, participants will always have a different version of the installation art at a specific time. For example, the signing of blocks could not be done on the very first day since no blocks were yet printed.

The preparation before the opening of the installation art, included the following 1) the design of the allocated space, 2) the 3D modelling of the Chinese character and computer generated pattern to create individual blocks, 3) finally, the fine-tuning and experiment of the 3D printing software settings. The preparation time pre-exhibition took three weeks to define the best settings, source all materials and equipment and design the space organization.

### 3.2 Design

The design of the Chinese character is based on a standard Chinese font character which has been used in Autodesk Fusion 360<sup>5</sup> to create a base version of the character. Consecutively, we design our own version of the character, keeping similar proportion from the original font. Following the 2D drawing, the 3d model was designed with a 3D extrusion function. Since the 3d model of the character was 2-meter-high and we wanted to use consumer grade 3d printers only, it was not possible to print it in one piece. It was important for us to use off-the-shelf 3d printers to allow participants to be able to see the possibilities and limitations of existing and affordable 3d printers. In order to not generate simple cube, we choose to cut the model with a Voronoi diagram [8, 9] generated pattern applied to it. This type of pattern allowed us to generate unique, distinct and controlled-size geometrical shapes through a set of pre-defined input parameters. It then allowed us to obtain geometrical shapes that could fit in the 3d printers used for this installation. Based on this pattern, we generated a total of one hundred and twenty blocks, all different from each other. The final part was to export all those 3d shapes one by one and organize them for the next step.

### 3.3 3D Printing

3D printing, like all digital fabrication technologies such as laser cutting or CNC milling, is constitute of 2 distinct and complementary parts: the first is software based and the second part is mechanical based. Regarding the software, it is a digital model created on a computer based software, either manually



**Figure 3: The installation art in progress. On the left along the windows, the 3d printers; on the right the stand for all 3d printed letters; on the front the play area for interaction with letters. The Chinese character on floor was just completed and on the way to finish the gluing step. Photo taken on December 29<sup>th</sup> 2016.**

created by a human or generated through mathematical algorithms by the computer itself. The second is a physical part where a fabrication machine will transform bits received from the computer into actions and movement to create a physical representation of the model. The Chinese character was no exception to this process. First, the character has been designed and then processed to send to the 3d printers. In a second step, the machine interpreted the file to build the physical representation.

#### 3.3.1 Software Workflow

Following the design work described earlier, we generated one hundred and twenty 3D files in STL<sup>6</sup> file<sup>7</sup>, each one with a distinctive Voronoi-based shape. Once all blocks are exported from Autodesk Fusion 360, we used Simplify3D<sup>8</sup>, a proprietary 3d printing slicer software, to prepare specific machine code based on a set of predefined rules<sup>9</sup> and generate the final G-code<sup>10</sup> file for each block; each file code was specifically architecture-targeted since each machine have different parameters and physical characteristics such as the nozzle size, the initial heating process and of course the bed size. Each

<sup>6</sup> Stereolithography [https://en.wikipedia.org/wiki/STL\\_\(file\\_format\)](https://en.wikipedia.org/wiki/STL_(file_format))

<sup>7</sup> the most used 3d printing file format

<sup>8</sup> <https://www.simplify3d.com/>

<sup>9</sup> Layer height: 0.38mm, Infill: 0% (the 10 bottom blocks on each side were printed with 10% infill to give them more strength), Shell (outside walls): 3 (~1.5mm), Top layers: 5, bottom layers: 3, XY Speed: 100mm/s.

<sup>10</sup> Machine instructions <https://en.wikipedia.org/wiki/G-code>

<sup>5</sup> <https://fusion360.autodesk.com/>

generated file was then sent to the queuing system of each 3d printers to be ready to be 3d printed and create the physical representation of the computer generated 3d model.

The settings are important since they define the quality of the final print as well as limit the number of fail prints during the period of the installation and more importantly they also define the printing time for each block, which is a critical parameter in a live exhibition to ensure the completion of the prints within the planned timeframe of 7 days. Pre-exhibition, we tested different settings in order to find the optimal option to output the best compromise between printing quality and printing time.

### 3.3.2 Hardware

Regarding the 3D printers used in this installation, as mentioned earlier, the objective of this project was to be able to use consumer-grade 3d printers, all of them within an open-source and open-hardware license<sup>11</sup> and in a price range lower than 3,000USD. These printers are all using the same 3D printing technology “Fused Deposition Modeling”<sup>12</sup> which is the most common 3D printing method and the most affordable currently, using thermoplastic filament to create physical representation of a 3D model.

All printers were remote-controlled on the local network using an open-source application: Octoprint<sup>13</sup> running on a Raspberry Pi version 2 attached to each machine. This software allows us to plan the printing process as well as record statistical information<sup>14</sup> and finally notify the artist once a machine completed a job or a failure happened.

Each block constituting the Chinese character was printed in white color with Poly-lactic acid<sup>15</sup> filament, also known and commonly referenced as PLA, a biodegradable thermoplastic polyester. This thermoplastic is commonly used in the 3D printing industry for its ease of use as well as its low pricing. The white color was chosen in order to use the final two-meter-high standing character as a screen for a generated spatial augmented reality projection.

## 3.4 Assembling

All the one hundred and twenty blocks were glue together based on the technical drawing generated from the original 3D model of the character. The glue used was a 2-parts<sup>16</sup> epoxy glue and the standard curing time was about 24 hours. It was important to

<sup>11</sup> Two Lulzbot Taz5, with their large printing bed area they have been printing the largest blocks, One Lulzbot Mini, One Ultimaker 2, One Micromake Kossel, an inexpensive machine built by our team in a previous project.

<sup>12</sup> Technology trademarked by Stratasys Inc and commercialized in 1990. Patent expired in 2009.

<sup>13</sup> <https://octoprint.org/>

<sup>14</sup> Information recorded per file printed: date, time, duration, length of thermoplastic used.

<sup>15</sup> [https://en.wikipedia.org/wiki/Poly-lactic\\_acid](https://en.wikipedia.org/wiki/Poly-lactic_acid)

<sup>16</sup> a 1 to 1 ratio between an epoxy resin polymer and a hardener mix



Figure 4: The “Play with Letters” as well as the spatial augmented reality projection in the background where will stand later the character. On the left, the signing of one of the blocks. Photo taken on December 17<sup>th</sup> 2016.

find a glue with a high strength bond coefficient but also a high viscosity to allow the glue to fill some of the gap due to the imperfection of the 3D printing.

## 3.5 Spatial Augmented Reality

Since the Chinese character was printed in white color, it was then used as a projection screen for a spatial augmented reality [10] projection (also known as projection mapping or video mapping).

During most of the time of the exhibition the Chinese character was not fully constitute since it was printed on-site block by block. It was important to explain what was on construction and give a virtual view to the participants on how it will look by the end of the construction period.

A generative video animation with sound was created<sup>17</sup> before the exhibition to highlight the following aspect of the Chinese character: 1) the size: since the final object was a tall sculpture of two-meter-high, the animation had to be at real scale; 2) the space: at the beginning the space was empty and it was important to keep the space alive, at least digitally.

We actually displayed the projection mapping since the first day on the spot where the character will raise two weeks later, it helps visitors to understand what was happening and to measure the progress and completion of the installation.

<sup>17</sup> Using Apple Motion 5 software

### 3.6 Interaction and Participation

One of the research question regarding this installation was to create interactions and experiment the playability of 3D printing objects in a public space. It was important for us in this exhibition to allow interaction between participants and the installation. At the same time, we did not want to add complex interactivity and computerized systems, we wanted to show that participation and to some extent interactivity is not necessary requiring a lot of complex technical systems but instead the conditions for participation are accessible with low level technologies.

We designed 3 levels of interaction for the visitors to encourage them to become active participants.

#### 3.6.1 Direct Interaction: signing

Participants were invited (through a bi-lingual poster or verbally by the staff) to sign with a personal message at the back of a 3D printed block before we glue it to the main Chinese character. This interaction was designed to be a long-term interaction and was a strong action for the participant in the sense that it is a permanent change to the Chinese character, their message and signature will stay on the 3D printed block long after the temporary exhibition finished. In other words, one person bounds to a block to make each block related to a unique human being.

#### 3.6.2 Participative Interaction: Play with Letters

During the pre-exhibition period, we 3D printed 40 colorful capital letters<sup>18</sup> from the western alphabet, including some double for the most popular letters (such as “E”, “A”, “S”, etc.).

Participants were invited to touch and play with the big colorful letters in their very own creative ways, using them the way they can imagine; essentially to make a word to send a message or simply their personal initials, their name or someone else.

This part of the installation was designed to give a temporary playful environment for both children and adults as well as a representation of the bi-cultural environment of Macau: between Easts (Chinese character) and West (Alphabet letters). To the contrary of the direct interaction mentioned on the previous paragraph, this interaction allowed temporary and very short-term participation that could be erased at any time by the participant which lower the personal engagement and commitment and make it more as a play.

#### 3.6.3 Collaborative Interaction: Photo and Sharing

Finally, the collaborative interaction was inviting participants to take photos or selfies with any 3d objects or machines and share them on their favorite social networks such as Instagram,

Twitter or Facebook. We also proposed 3 hashtags dedicated to the exhibition and participants were invited to use them as well when they were publishing and sharing their photo. These hashtags were the following: #wearehumans, #3dliveprinting and #3dyancharacter.

## 4 RESULTS AND DISCUSSION

### 4.1 Methodology

The methodology taken to collect data was 2 folds: 1) by quantitative data and 2) qualitative content analysis (observation).

During the open days, we setup a camera covering all the exhibition area and recording a photo time-lapse every 30 seconds. We then collected those photos to collect data about participants’ activities and interactions. Based on these photos we created a data analysis spreadsheet to identify the key areas we were interested to study and covering each aspect of the installation art and participant interaction.

We also added a visual observation which allowed us to take notes on non-common pattern or interaction. This method helped us detect interesting interaction that we did not necessarily anticipated.

### 3.2 3D Printing Data

As mentioned earlier, the Chinese character was composed of 120 individual blocks and the total dimensions are: 2.1 meters high, 2.2 meters wide and 0.1 meter deep.

We collected data from the 3D printing process as well as the assembling process, here are the keys values collected:

**Table 1: 3D Printing Analytics**

Total 3D printing time	194 hours
Total weight of thermoplastic used	14kg
3D Printing Failure Rate	12.2%
Quantity of Epoxy Glue used	400ml
Total Assembling Time	45 hours

To our knowledge, it was the biggest Chinese character ever 3D printed.

<sup>18</sup> Each letter is 22cm height and 5cm wide

### 4.3 Interaction and Participation Study

Over the period of the exhibition we received a total of 98 participants. The following analysis is based on this total number.

We identified 5 areas of studies, namely:

**Table 2: Interactions Frequency and Percentage**

Interactions	Participants
3D Printers	61
Artists or staff	58
Signing	41
Play with Letters	48
Photos	41
One interaction at least (any of the above)	96

#### 4.3.1 Interaction with 3D printers

We identified if participants spent more than 1 minute around the 3D printers and if they talked or asked questions about them.

62% of participants spent some time to watch 3D printers in operation and asked questions about them.

Among these 61 participants, we always asked them 2 questions:

**Table 3: Knowledge on 3D printing**

Questions	Percentage
Have you heard about 3D printing before?	79
Have you seen a 3D printer before?	34

It is interesting to notice that while a high number of participants (79%) heard about 3D printing technologies before coming, only a third (34%) have actually seen one.

#### 4.3.2 Interaction with Artists or staff

We identified if participants engaged a discussion of more than 1 minute with the artists or the staff of the exhibition center.

As shown in Table 2, almost 60% of participants spent time to discuss with the artists while visiting the exhibition. Since the installation art was a live process, the artists were present on site most of the time, it allowed for a high interaction with participants.

#### 4.3.3 Direct Interaction: Signing

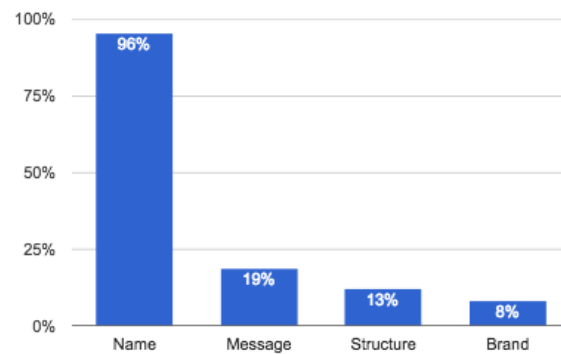
We identified if participants agreed to sign one of the 3D printed block. As we mentioned earlier, the signing of block can be viewed as a strong interaction, since the signing block will be view by other visitors and will remain for a long period after the

initial exhibition. As such only 42% of participants engaged in this activity.

#### 4.3.4 Participative Interaction: Play with Letters

We identified if participants engaged and played with the 3D printed letters for more than 1 minute.

Table 2 shows that half (49%) of the participants engaged with the 3D printed letters. For this specific interaction, we also looked at the children engagement (under 18 years old) and we have identified that nearly all of them (98%) played at some point with the letters. We also analyzed the type of play and we identified 4 different types represented in Figure 5 below.



**Figure 5: Types of Play with Letters**

It is interesting to note how participants played with letters in different creative ways<sup>19</sup>:

- Name: 46 participants out of 48 (96%) used letters to write a name.
- Message: 9 participants (19%) used letters to send messages such as “Happy New Year”, “Merry Christmas” or “Happy Birthday”.
- Brand: 4 participants (8%) used letters to promote one of their favorite brand.
- Structure: 6 participants (13%) used letters to build vertical or horizontal structures.

Finally, we counted 39 participants (81%) playing with letters and taking photos (by a third-party or as selfie).

#### 4.3.4 Collaborative Interaction: Photos and Sharing

We identified if participants took some photos.

Table 2 shows that 41 participants (42%) took photos during their visit; on this number, 39 photos (95%) took photo including the letters and only 25 participants (61%) took photo including

<sup>19</sup> We only suggest the play with names.

the Chinese character. The difference is simple to explain: the Chinese character was only fully assembled in the last 2 days of the installation art.

We could not get reliable data regarding the sharing on social network unfortunately<sup>20</sup>. Although there is no valuable study on social networks usage in Macau, our experience with students at University of Saint Joseph<sup>21</sup> show us that Facebook is by far the most used social network, Instagram far behind and Twitter almost non-existing. More importantly, most local users are not used to share with hashtags.

## 5 CONCLUSIONS

In this paper, we described an installation art based on 3D printing objects.

The Chinese character was successfully completed in time (both 3D printing and assembling), which is always a challenge for a live event such as this one. We demonstrated that even if 3D printing can have a high fail printing rate (15% in our case), it can still be used for installation art and even live exhibition. The 3D printing process has been one of the most visited area of the exhibition. We also identified that although most people have heard about 3D printing, most of them never actually saw a 3D printer working in front of them.

From the evidence we have gathered, we conclude that 3D printed objects have a high potential of playability and to engage and create interaction with participants. Indeed, since 98% of visitors interact one way or another with the installation art, we believe that these types of objects can easily encourage participants to play.

We can also suppose that 3D printing objects are very often unique pieces designed for a specific need, something that participants will not find anywhere else, therefore these objects by their nature increase the natural curiosity which open the door to a potential play later on.

Our future plans are to explore and analyze in more details a collaborative and interactive installation art, its playability and then identify a systematic way for creativity in this particular context.

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<sup>20</sup> Several reasons for this limitation in our study: 1) lot of them shared photos after visiting the exhibition, and 2) 80% of participants, according to an informal oral survey during the exhibition period, are using Facebook only and are not used to hashtags therefore it was almost impossible to collect relevant data on sharing photos on social networks.

<sup>21</sup> <https://www.usj.edu.mo/>