fractaL

[A TOOL FOR DIGITAL LITERACY

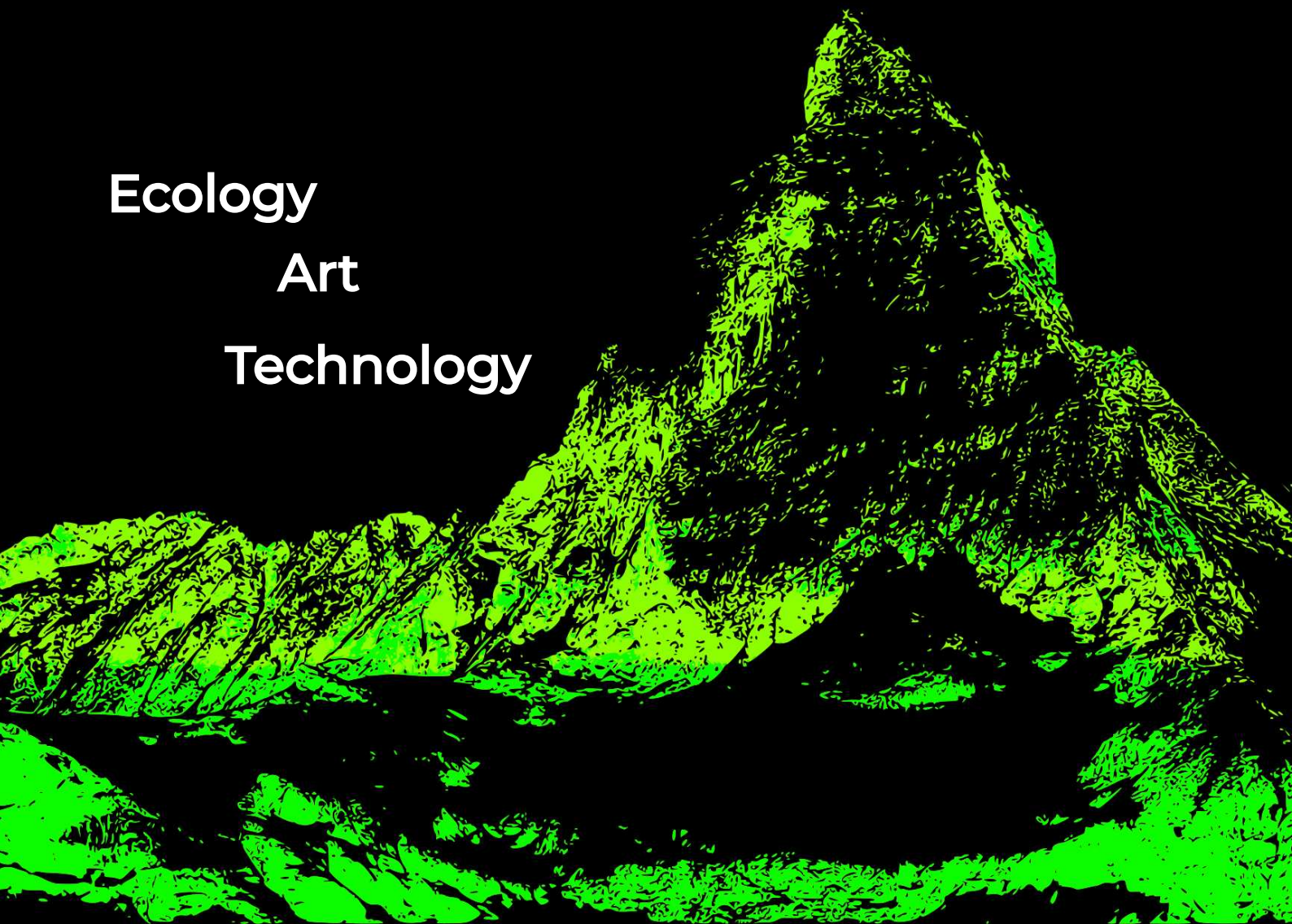
&

ECOLOGICAL THINKING]

Ecology

Art

Technology



Introduction

Currently we witness a strong change in the climate of the planet that affects both living and non-living environmental components in a never seen velocity and intensity. From big mammal migration to the air circulation, from extreme drought to new epidemics, the human activities and the fast urbanization had resulted in an unprecedented environmental impact. Although the world becomes more and more connected, the massive amount of data and information promotes more noise than opportunity to enhance critical evaluation, knowledge, and consequently a social mobilization to overcome this systemic crisis. Additionally, the lack of contact with the scientific process combined with the fact that in technology society in general is not participant in the creation of content, result on a passive condition where science and technology are centered on a small group of people that in general ignores the social realities.

The project **fractaL** starts from this context. Built up by an interdisciplinary group, the project aims to promote an integrative perspective focused on the ecological issues and the use of free-open technologies as tools for learning, practices and applications of knowledge. In terms of "doing science", fractal is placed beyond such a kind of activity, it is moved by the understanding about the importance of the abstraction and that this concept is not detached from scientific thinking. The traditional use of environmental data gives a perspective to model nature according to calculable parameters that fits perfectly in the machines and superprocessors logic. With **fractaL** we aim to open up new ways using a complementary approach of numbers (environmental data) with the uncountable (synesthesia using fractal principles) in which cognitive aspects are activated, and creativity and knowledge are put in practice.

Using Fractal – A Bottomless Wonders From Simple Rules

The project is based on the fractal concept of systems and use environmental data to represent it using synesthesia techniques. The term Fractal Geometry is used in science to address the roughness that is characteristic in natural structures, far from the smooth

structures and shapes created by human. First systematized by Benoit Mandelbrot, it revolutionized not only mathematics, but also ecological studies once limited by a Euclidean conventional geometry. With fractal geometry, ecology and environmental studies reached a never seen capability to explain more complex and systemic issues once constrained by old paradigms.

This concept will be associated to *synesthesia*, a phenomenon in which stimulation of one sensory or cognitive pathway simultaneously produces a sensation in a different one. This "phenomenon" could be pointed as the very base of many artistic practices and cultural manifestations. In **fractaL** we use two techniques to translate the environmental data through Synesthesia: *sonification* (the transformation of arbitrary data to an audible representation) and *visualization* (the arbitrary data transformed to images). Both techniques are being used to represent biological diversity, temperature variation and other environmental information.

Historically, many groups had already integrated science, art and technology, but rarely they explored this integration as an instrument for the development of activities considering the existing relationship between ecological studies, digital literacy and arts with a local narrative. In this sense, the project **fractaL** considers as essential that this integration takes into account principles such as flexibility, scalability and modularity for using straight to public exhibition, developing an interactive online platform, or for its integration in an already developed project. This characteristics also represent its potential to be implemented in different places of the world.

As a project strongly based on the open science and open technology, **fractaL** develops its workshops and courses on digital literacy aiming the ecological knowledge, the open communication and experience sharing. Thus, the project's objective is a long term strategy in which the *Python in Education*'s support will be central as the first stage to create a solid base to its development, the workshop implementation, the contemplation of a big number of youth and the strength of the connection between groups that are already active around the project.

As a long term strategy to ensure the project's sustainability, our objective is to create partnership with schools and research groups, as well as seeking for funding from groups

committed to open technologies, open education and open science. This will make possible to combine the intention in offering both, free and paid versions, for the courses and workshops focused on accessibility and equity.

Methodology

The project has been planned to be developed for 10 months and starts with a synesthetic exhibition and small workshops which will be released in June. This will be part of the promotion of the project, as well as the spatial and functional structure that will be the guiding line to introduce the concepts of programming language. To this structural-based approach of teaching there will be two strategies: (1) a workshop will follow, accomplishing **2 hours offered periodically and during exhibition events** for a broad audience and (2) a course of 5 classes and **4 hours** each, developed at a makerspace and a technology center for students, accomplishing a **total of 20 hours of formation**.

The classes will cover concepts on free and open technology, environmental monitoring and the relation with Citizen Science. As a strategy to offer an intelligible overview about the subjects even to participants that eventually are unable to attend all courses, the curriculum was developed as modules in which the studied subjects will be applied on the development of small projects in each meeting. At the end of the 20 hours of course the participants will be capable to explore python and Processing.py by themselves and to have a systemic approach of knowledge considering environment, art and technology. Despite of this curriculum structure, the selection of candidates prioritizes who is interested and can attend to the whole course.

The course will cover also the use of *Python* on Physical computing (Arduino-like and Raspberry Pi) for environmental monitoring, for its integration with **fractaL** and to know how to build up a web-server.

Dataset, Code and Application

The **fractaL**'s code is developed to ensure a strong tool for both learning and environmental studies. Accordingly, our intention is to build a code where both the experienced and beginner user can access, study and use it for his needs. Thus, the code brings both a set of functions dedicated to Synesthetic representation and a set with the most frequent data and statistical analysis used in environmental studies. The objective is to cover a big number of environment dataset which can be accessed from open data initiatives and from monitoring systems developed as a complementary part in the project. Currently fractaL has a dataset covering mainly aquatic ecosystems with 10 years of long term ecological research in tropical lagoon and three years of amazonian rivers and lake. This is the starting point and the base supporting the development of the code.

The functions dedicated to exploring and analyzing data use mainly the scipy, numpy, pandas and matplotlib applied to data analysis and descriptive statistic. In this case, **fractaL** uses the *numpy*, *scipy* and *matliplot* for descriptive analysis, distribution tests, data manipulation and visualization. The pandas is used for processing JSON and CSV files, time series, data frame, and panel.

The synesthetic implementation will be divided in two groups: (1) a non-interactive exhibition based on data set and sensors information, and (2) simulation of the environmental impact on the ecosystem dynamic for interactive installation. For the first 10 months the objective is to focus on the non-interactive approach. The synesthetic tools have been developed in parallel data analysis development since the early stages of the project. With them, **fractaL** intends to offer a strong code for each step of environmental data analysis and its implementation using synesthetic tools.

This set dedicated to synesthesia is composed by the code for image representation using Processing.py, a robust platform for image projections and interactive visualization. On the other side the code for sonification is built using mainly on the modules MIDITime, Pygame, scipy, numpy and pandas.

For further details the code can be accessed at: https://github.com/ecofractaL/fractal

Activities

Workshops Courses and Meetings

The main workshops are focused on youth 14 – 18 years old with little or no programming experience, considering the social and gender inequality markedly present in technology and science. The workshops will be regularly offered in partnership with the Made Maker Space and Lleialtat Santsenca located at the Sant's neighborhood in Barcelona. In Brazil, the project was invited for a series of activities between January and February 2020: to a 1 month training in Rio de Janeiro at a place yet to be confirmed and four workshops in São Paulo at the SESC Sorocaba. For all of these activities, the participants attending will come mainly from local regions but will also contemplate youth coming from other neighborhood and regions able to participate to the activities, prioritizing public schools and social vulnerable areas.

The objective of **fractaL** is to reach a total of 300 youth and also their teachers and/or facilitators interested in getting involved and in eventually adopting the **fractaL** program as a complementary activity at their high schools. This number can increase considering that the small workshops placed during the exhibition will reach at least 20 participants for each activity.

The workshops are structured focusing firstly on Processing.py. This approach aims to present an intuitive introduction that will help the participants to understand the language and how to create a program by using principles of *Python* (variables, types, loops and so on) on experimentation with data manipulation, interactive interface and generative design. The archive dataset used to both visualization and sonification is composed by coastal lagoons, lakes, rivers, reservoirs, microcosms and air. While the real-time data will come from air, water and soil sensors.

After this first contact with *Python* the next steps will be the coding using Jupyter and Spyder. At this point, the students will be familiarized with *Python* principles and a more interactive approach will be put in practice: the use of a predefined framework composed by data – mapping – synthesis engines, integration of *Python* file and Processing.py. Lessons cover *Python* syntax, basic and advanced concepts, as detailed in the “supplements” section.

The use of *Python* as the language for all activities is due to its principles as a programming language, as well as to its power and versatility to be applied from basic coding to more complex and integrative purposes. Particularly, in the case of **fractaL** *Python* is used for data analysis, data visualization, synesthetic representation and integration with hardware and physical devices.

Important to note that **fractaL** considers documenting each step, because our aim is to make possible the project replications by different groups interested on the concept of a learning tool interaction with artistic works and environmental data. This integrative approach of many steps ensures the use on synesthetic tests and the integration with other projects and open source monitoring systems.

Under a socioeconomic aspect, the project will provide a set of skills for qualification of youth at a local and global context considering the application of *Python* on different activities, such as scientific studies, data analysis, machine learning and primary activities.

The Hackathon and Extra Activities and Places to Receive fractaL

The Hackathon will take place in Lleialtat Santsenca, and has two objectives in **fractaL**. It is the activities' conclusion, where the works developed throughout the course are exhibited and the broad audience has contact and can access to the project.

This event is also an opportunity to the student-developers to contact directly *Python* experts, researchers and artists, and to look for improvement of the works for future development. For this event there is already a group of professionals willing to attend, including interactive forms as video-calls during the weekend dedicated to the event. In fact, the structure thought for this event is prioritizing the *Python* developers and researchers from the nearby region, and counting also with the participation of specialists from other regions by videoconferencing. This will make possible for the event to reach a bigger number of people than if it was thought only considering the region of Barcelona.

The Hackathon will be gathering together the students-developers, members of *Python* community in Barcelona and Citizen Science groups from Barcelona, Zaragoza, Sao Paulo, Quilmes and Rio Grande do Sul, that can attend remotely to the meeting.

Material and Documentation

The project's documentation will cover the research, adjustment, execution, as well as the classes and workshops. All these contents will be freely available at the platforms used by **fractaL**, distributed during the events and informed in social networks.

For documentation the project uses the Read the Docs as well as the Wiki and Issues sections at the Gitlab repository (https://gitlab.com/ecofractal/fractal). These areas are available also through the **fractaL** website. The website was developed to offer a general idea of the project and also to organize the material produced in the workshops. It will ensure the access to the digital material produced during the activities. The materials such as art, folders and others will be created using open reproducibility. These materials will also be freely available in digital open format (SVG, PNG).

Release and Promotion

Communication strategies

Our focus will be to announce the program in local spaces and public exhibitions will be our first action to promote the project. These performances will take place in spaces like cultural, artistic and civic centers, or free technology centers like Fablabs and Makerspaces. For the workshop activities the public will be a small group up to 20 people for each activity, selected from a broader audience, including teachers and educators that will be expressly invited to attend. They will have an important impact and outreach potential considering their active role in educational planning.

As an additional promoting act, we plan to build art exhibitions in public spaces, such as squares and other urban areas where young people (14-18 years old) often go and meet (e.g next schools or sport areas). These exhibitionsare possible once the interactive part is ready and will be performed by the **fractaL** coordinator and includes images and sound projections on public spaces.

Local community partners such as associations and civic centers are key-actors that will also promote the project in the community by relying on their network of members and collaborators.

Public schools and teachers will be also reached to target and organize groups of students that will attend the classes, directly or through selected intermediary partners.

The communication will also be supported by content in our website, digital media and networks. We will launch the news and program of **fractaL** through both local offline and online media and newspapers.

The digital and audiovisual materials created in the classes will be uploaded in the website, published weekly in the social networks, and will become gradually constitute the public exhibitions; all the didactic material will be shared using open-friendly platforms, such as “Read the Docs” and the Gitlab repository.

Additionally, the final Hackathon is part of the didactic, as well as a promotional strategy of **fractaL**. The collective experience will host groups of students and experienced

Python programmers working together to guide and boost each other, and the event will include the presentation of work from each group to a general public.

We will offer a space in our website for the participants to keep in touch and be part of the **fractaL**'s Community, sharing useful information and new opportunities to learn, create and collaborate. We intend in the future to develop the project to offer online webinar or courses, so that interested members will be able to further improve their skills. This last point can also partially support the project and help to make it economically sustainable in a long term perspective.

Implementation

The campaign phase is planned to start in the second half of June during activities of exhibition and workshops. In early July the campaign will be extended with the announcement at digital medias, public spaces associated to education and training activities (Civic Centers, Maker Spaces, etc) and schools – where we expect to already have a dialogue since the previous activities of public exhibition and workshops.

This activities will precede the inscriptions phase that will start at the end of June till the end of September 29th and the final result published at October 3rd according to our principles to know: gender equity, local-regional community and social inclusion. Those criteria will be assure by an external group composed by members committed to the principles of the **fractaL** which are also a commitment to the *Python Foundation* principles. From October 2019 till May 2020 classes will take place up to the final event in June. This event will also be the launching pad for the program for the year 2020. Further, the schedule will be defined according to the local school calendars.

Summary Table

Activity	Hours	Target	Content
Exhibition with presentation +Promo Workshops	1 + 2 h each workshop (considering a minimum of 15 exhibitions)	General audience, teachers and educators	Fractal Definition and Introductory Concepts
Street Art Exhibition	4 to 5 exhibitions (when the interactive part will be developed)	Young people between 14-18 years old	Artistic interactive exhibition with projection of images and music
Main Classes	5 classes of 4 hours (20h in total per course)	Young people between 14-18 years old	Understanding of *Python* package and application ecosystem. Learn *Python* Syntax through practice on manipulating data.
Hackathon	2 days	General audience, teachers and educators, participants of the Hackathon and 14-18 years old people.	Hackathon, presentation of fractaL development, the final projects presentations, the new year program development 2020

Challenge, Potential and Perspective

The *Python in Education* grant helps **fractaL** to overcome the barriers in a medium/long term perspective related to the communication and implementation of the project. This grant will be applied in order to raise interest at the initial phase through workshops to attract and involve the local youth and teachers on the activities, to strength the connections with those communities, to adapt the activities to each context and finally to build a project together with the community. The approach of self-contained workshops helps to mitigate the structural limitations of some technology center or school to promote long events (for example, projectors and speakers for a three day workshop).

The purpose of **fractaL** is also to communicate and collaborate to other projects. In this sense, the project sees a broad potential covering a diverse area: integration with climate forecasting, a tool for environmental education and a source for interactive project. This potentialities are important since they make possible the development of an integrated workshop that promotes the potential of *Python* for being applied on different context.

Currently **fractaL** already has this kind of partnership with the development of **Alquibots** + **fractaL**, based on the interactive feedback between robots built up using low cost material and **fractaL**. This collaboration is also intended to be materialized with at least two workshops in Barcelona during the second half of June 2019.

All those described characteristics confirm the relevance of **fractaL** as a project promoting learning (both in the programming language literacy and the environmental consciousness) and enhancing the sharing of knowledge, and technical skills applied from economical activities to scientific studies strongly based on ecological principles. In this sense we see **fractaL** as a powerful tool where the *Python in Education* grants will ensure the implementation of the project and the training as previously described.

Budget proposal[1]

The **fractaL** project has a long term perspective based on key milestones to make it possible. Accordingly, for this proposal we first consider the funding for 10 month of intensive activity, as previously described (and defined as proposal 1). We opted to also include alternative budget proposal in order to fit in the *Python in Education* strategy and perspective.

Proposal 1 – Development, Course and Workshop, Hackathon and Other Events

This proposal cover the costs of development (software, hardware integration, hardware devices) and the associated activities (project management, communication, partnership), the teaching/learning planning and activities (workshop, hackathon and classroom costs), the material that will be used during whole project (hardware, projector, speaker and peripherals) and the logistic/ administrative costs (fees, utilities, etc).

With this proposal it will be possible also to cover costs with extra activities in public centers and self-managed free-open technology, creative education and citizen science events.

Total budget: $30,014

Proposal 2 – Partial Development, Course and Workshop and Other Events

The second option compromises the hardware and the equipment such as speakers and projector. Although, the fund will make possible the development of fundamental part of **fractaL** related to the software and its practical application to the workshops and public events related to technology, creative education and citizen science events.

1 The detailed budget can be found in the spreadsheet sent attached to the application.

Total budget: $18,385

Proposal 3 – Partial Development and Workshops

This is the minimum viable to makes **fractaL** comes up to light, although it will be limited to cover the base of code's development code and the workshops focused specifically on the experimental sound and visual projection. This proposal covers the costs on the development of **fractaL** code, the workshop development and documentation.

Total budget: $10,275

Workshops and Courses

Workshop

Objectives

Introduction to **fractaL** and how it can be used to process environmental data in an intuitive way through sound and images.
Understand basic concepts of *Python* Syntax, its application to ecology and art.
The development of a functional representation using pyMIDI and Processing.py.

Contents

Fractal Definition
Basic of *Python*
Libraries in *Python*
Using Processing.py to visualization

Methodology

The classes are participatory learning activities mainly structured on *example-oriented and in which students will learn about the subjects along the way* while providing information and offering feedback to facilitate critical thinking. The basic hardware/multimedia devices used in the workshops are projector and laptops.

Public

This workshop is open to all. Individuals need no specific qualifications to enroll, nor do they need specialized training in the covered subjects.

Duration: 2 hours

Classes

Objectives

To get comfortable with *Python*.

Understanding of *Python* package and application ecosystem.

Learn *Python* Syntax through practice on manipulating data.

Assure that students will learn about the language along the way according to the on example-oriented practical cases.

Experiment with the code and development of a project based on **fractaL**.

Contents[2]

Python and fractal definition

Python Fundamentals

Modules and Packages

Python in Data Analysis and Ecology

Python in Data Representation and Art

Using Processing.py to visualization

Methodology

The classes are participatory learning activities mainly structured on example-oriented and in which students will learn about the subjects along the way while providing information and offering feedback to facilitate critical thinking. The basic hardware/multimedia devices the classes counts with laptops/PC, projector and video conferencing (when possible).

Public

This workshop is focused on Middle and High School students (14 – 18 years old).

Duration: 5 days 4 hours per day

2 Check the detailed *Python* content at supplementary information

Schedule of Activities

20 hours of Course

5 days – 4 hours

First Course: October – November 2019

Second Course: April – May 2020

Final meeting – Hackathon

- June 2019

15/06 – Public Exhibition and Workshop of **fractaL**.

- Open Call
- Application to the Course
- Workshop Activities at Lleialtat Santsenca
- Workshop Activities with Alquibots (place still to be confirmed)

July 2019

- 01 – Bring the campaign to digital media and public spaces
- Workshops Activities at Lleialtat Santsenca
- Public exhibition in Barcelona

August 2019

- Workshop Activities at Lleialtat Santsenca
- Workshop Activities at Made Makerspace
- Public Exhibition in Granollers

September 2019

- Project candidate for attending to EuroScipy 2019 in Bilbao from 2nd - 6th
- Workshop Activities at Lleialtat Santsenca
- 29th – End of application
- Workshop in Vitoria-Gasteiz

October 2019

- 3rd – Result of the inscriptions
- 15th – Beginning of course
- Workshop Activities at Lleialtat Santsenca

November 2019

- 23rd – End of course

January 2020

- 10th – Sao Paulo – Workshop at Red Bull Basement
- 18th – Sao Paulo – Workshop activities at SESC Sorocaba
- 25th – Rio de Janeiro - Workshop activities at place to be defined
- Public exhibition

February 2020

- 1st till 15th – Workshops at Quilmes University – Argentina
- 20th – Open Call: Application to the Course
- Campaign to digital media and public spaces

March 2020

- 1st – 20th – Workshop activities at Lleialtat Santsenca and Made Makerspace
- Public exhibition in Barcelona

April 2020

6th – Result of subscriptions

20th – Beginning of course

Workshop Activities at Lleialtat Santsenca

May 2020

23rd – End of Course

30th – Hackathon

Supplementary Information

1 – *Python* Curriculum

Processing.py, Jupyter, Spyder, Documentation

Introduction to *Python*: What is *Python*. Principles. Origin and intentions.

- Using the interactive *Python* shell
- Editing and starting *Python* scripts
- Fundamentals: Variables, basic data types and assignments. Operators and expressions.
- Conditional Statements: The details of the if statement and the conditions
- Branching Statements
- Looping Statements
- Dictionaries
- Lists and stacks
- Tuples
- Data Structures
- Sets
- Modules and Packages: Using and Creating
- Functions and recursive functions
- File Handling
- A short introduction into Regular Expressions
- Modules and Packages
- Decorators
- Generators
- Object-Oriented Programming (OOP) with *Python*
- Overview of Object-oriented programming
- Objects, Instances and classes
- Encapsulation
- Inheritance and the type hierarchy
- Polymorphism
- Regular Expressions
- Lambda, map, filter and reduce
- NumPy, Scipy, Matplotlib and Pandas

Fractal and Environmental Principles

- Fractal Geometry: concept and examples
- Fractal in Nature

- Differences between mathematical fractals and natural fractals
- Roughness, Landscape and Self-similarity
- Fractal: From aesthetic to biodiversity