CPAC MODULE1 PROJECT
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Crystal Harmony

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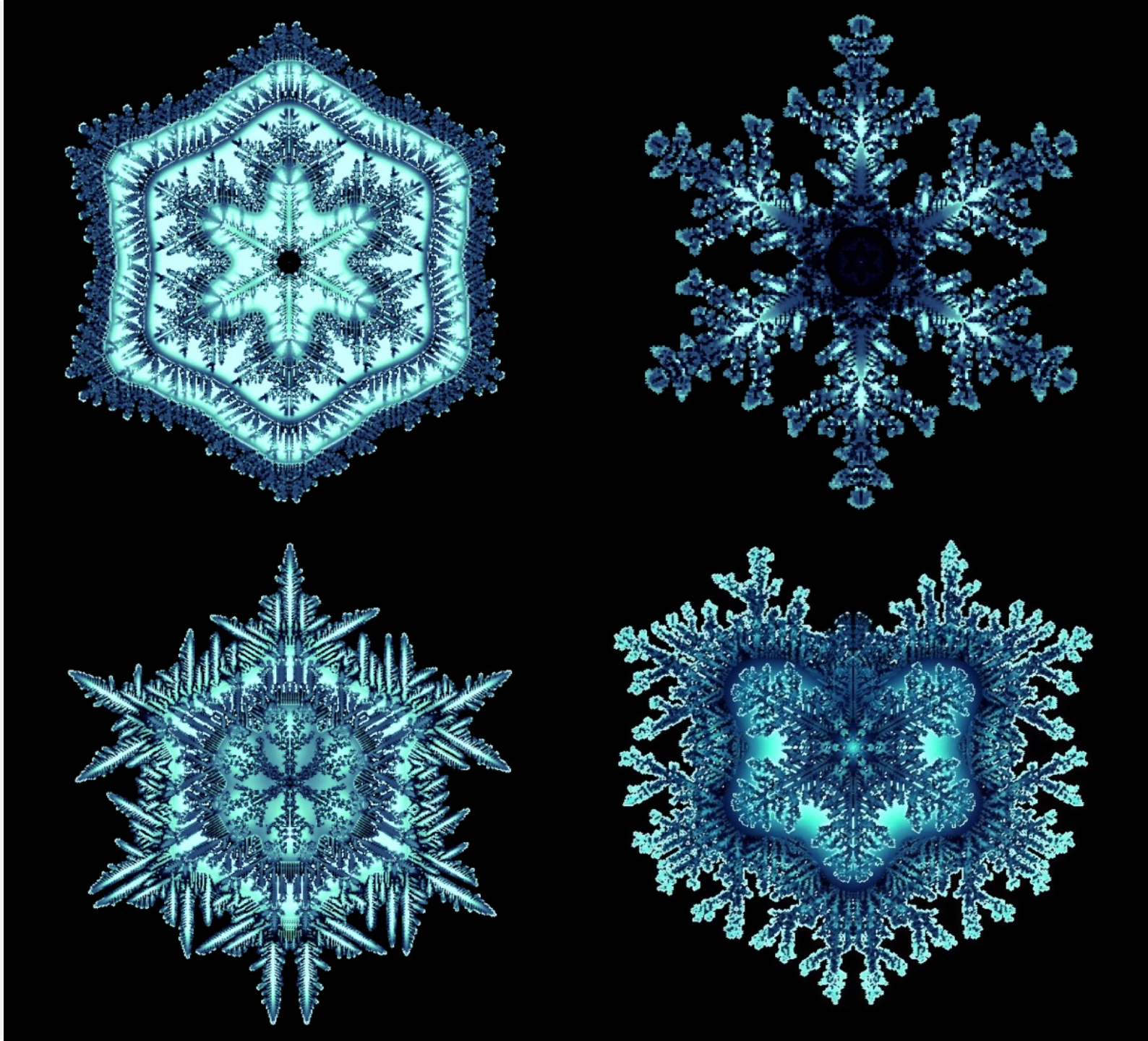


Context

- Program in which the human interaction is necessary for its functioning.
  - Human interaction: Musical Interaction.
  - Program behaviour: Generative Graphic Art.
- Program capable of preserving the musical features that make a tune and a performance unique and to exploit them to create unique designs.
- A tool for live music performances.
- Program that employs the concepts of: Multi-Agent Creative Systems, Complex Systems, Cellular Automata, Musical and Graphical Creativity.

Motivations

- “Boolean hexagonal automata can have behaviour surprisingly similar to a kind of snowflake growth.” [1]
- “Growth of a snow crystal in a homogeneous environment […] is primarily dependent on temperature, pressure, and vapor density.” [2]
- “Thoughts, feelings and music affect physical reality […]. By presenting music to the same water samples, the water appears to change its expression.” [3]
- “Different snowflakes each take a unique path and therefore they experience a unique set of conditions, which is why no two snowflakes are alike.” [4]

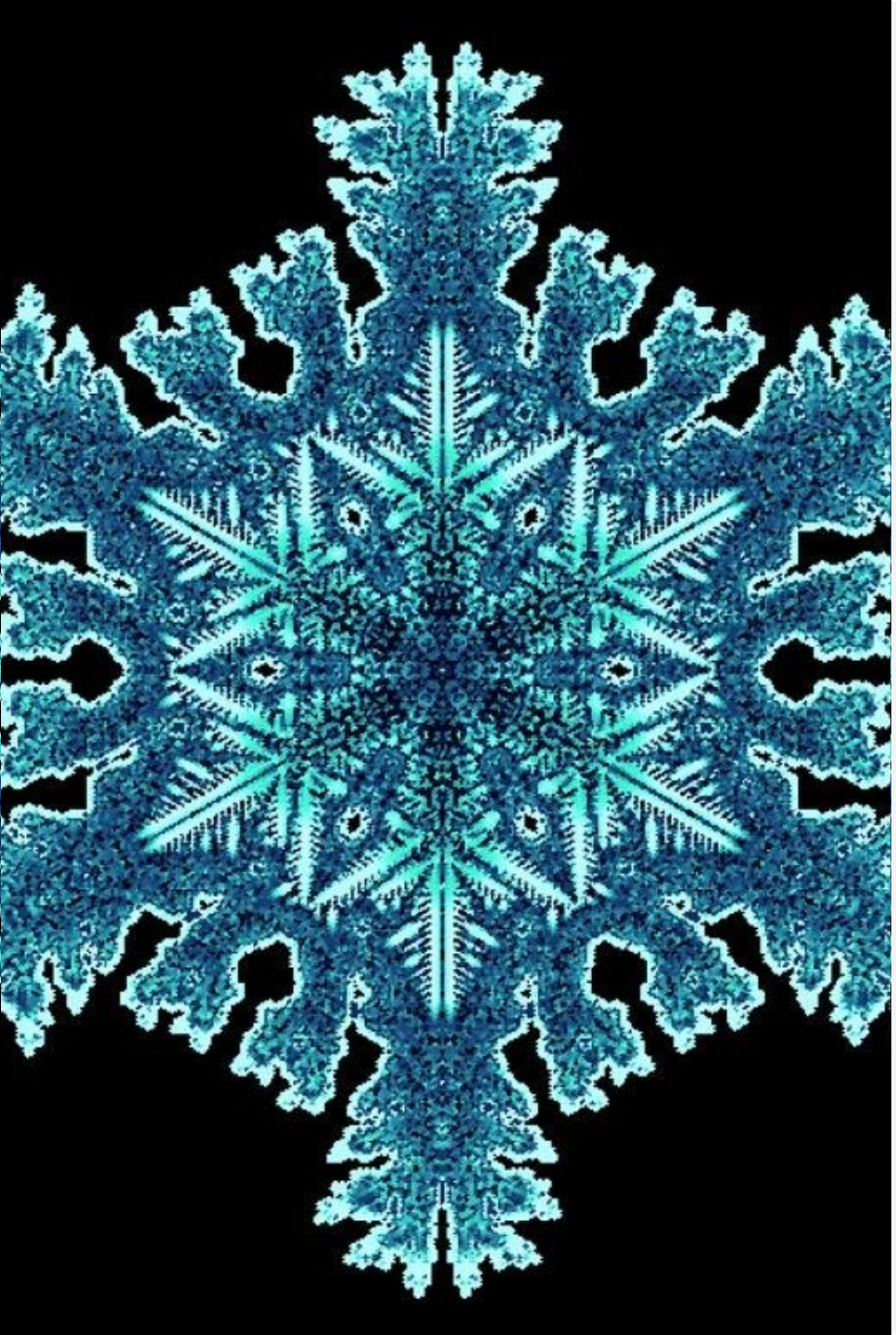
[1] Reiter C.A. (2005) *A local cellular model for snow crystal growth*, Chaos, Solitons & Fractals, https://doi.org/10.1016/j.chaos.2004.06.071.
[2] Janko G., David G. (2009) *Modeling snow-crystal growth: A three-dimensional mesoscopic approach*, APS, http://dx.doi.org/10.1103/PhysRevE.79.011601
[3] Dr. Masaru Emoto Shows the Effects of Playing Music (Madame Butterfly) on Water at WCQM, https://www.youtube.com/watch?v=gVbhSvT9-Fk
[4] Why are snowflakes like this? https://www.youtube.com/watch?v=ao2Jfm35XeE

Concept

- Snow crystal where music information (melody, harmony, timing, …) are the properties of the growing environment.

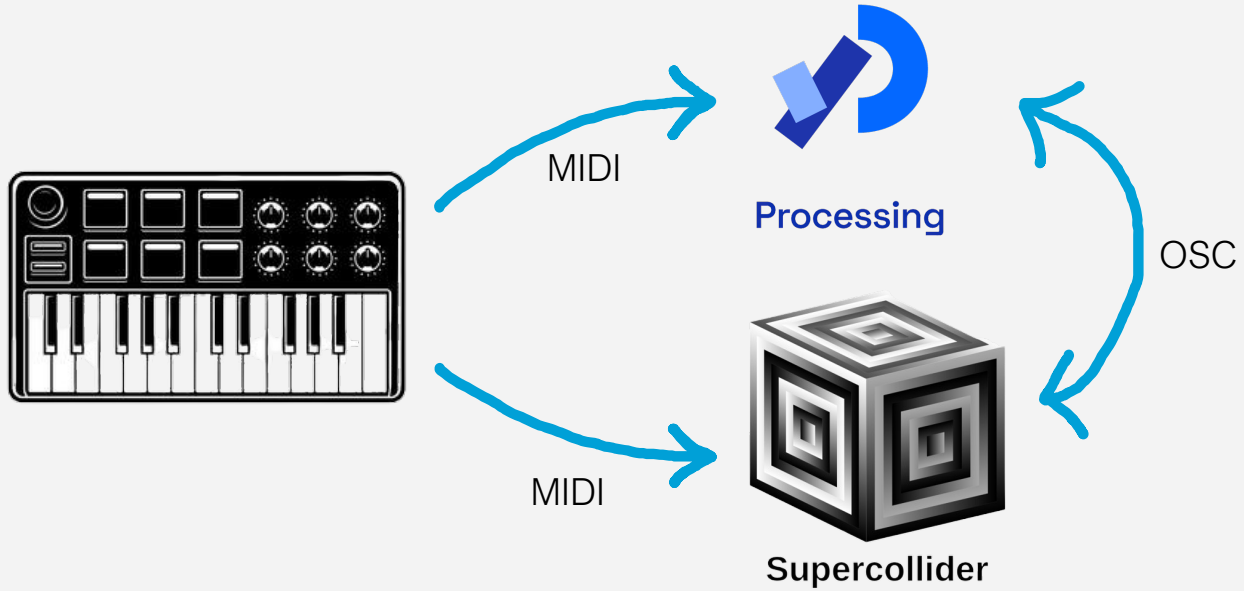
- The project is conceived to:
  1. Highlight the fundamental subjective features of a musical exhibition (uniqueness, grace, symmetry, elegancy, …).
  2. Offer the player a tool to enjoy music with the sense of sight.

- Inharmonicities, fast playing and silence affect negatively the growth of a snow crystal (negatively as they would be judged by a pedantic listener), while consonances and good playing produce a symmetrical and elegant snow crystal.

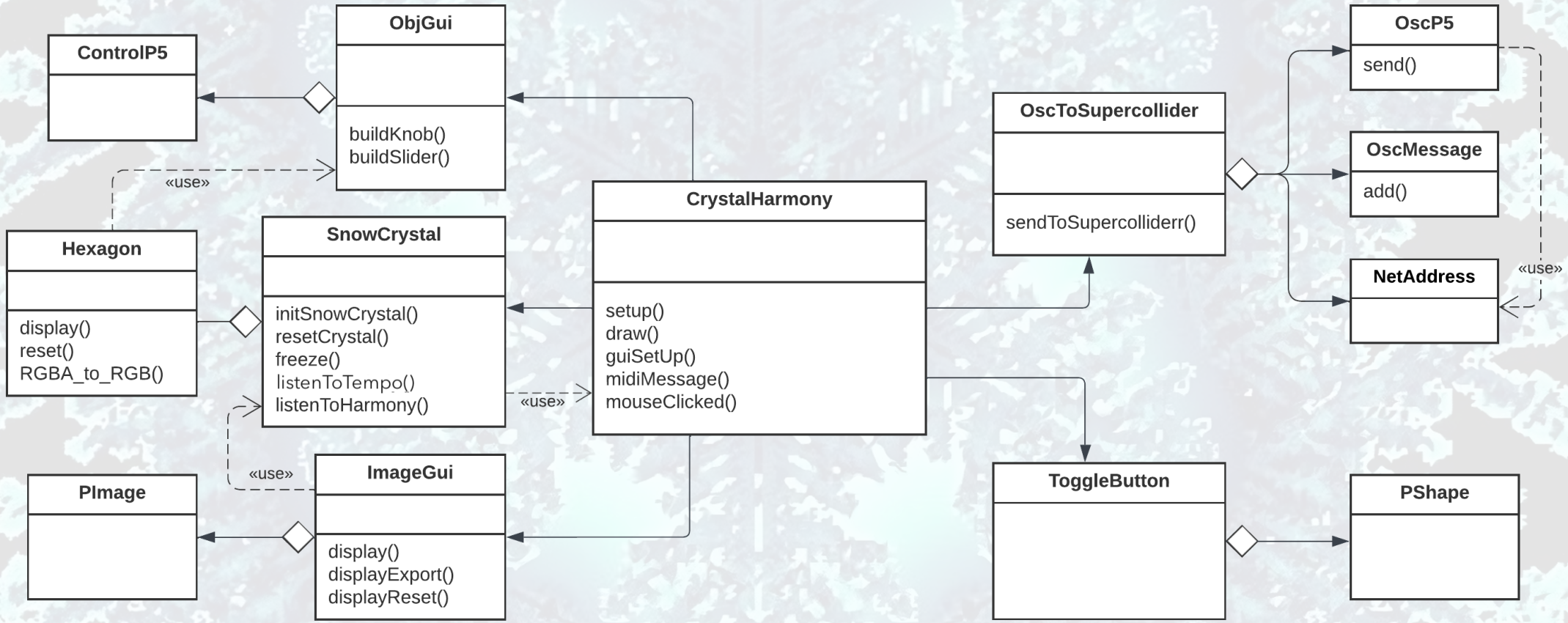


Technical Details

- The program uses Processing and Supercollider.
- The OSC and MIDI protocols are used to send musical information (note, velocity, volume, …).



Processing Classes



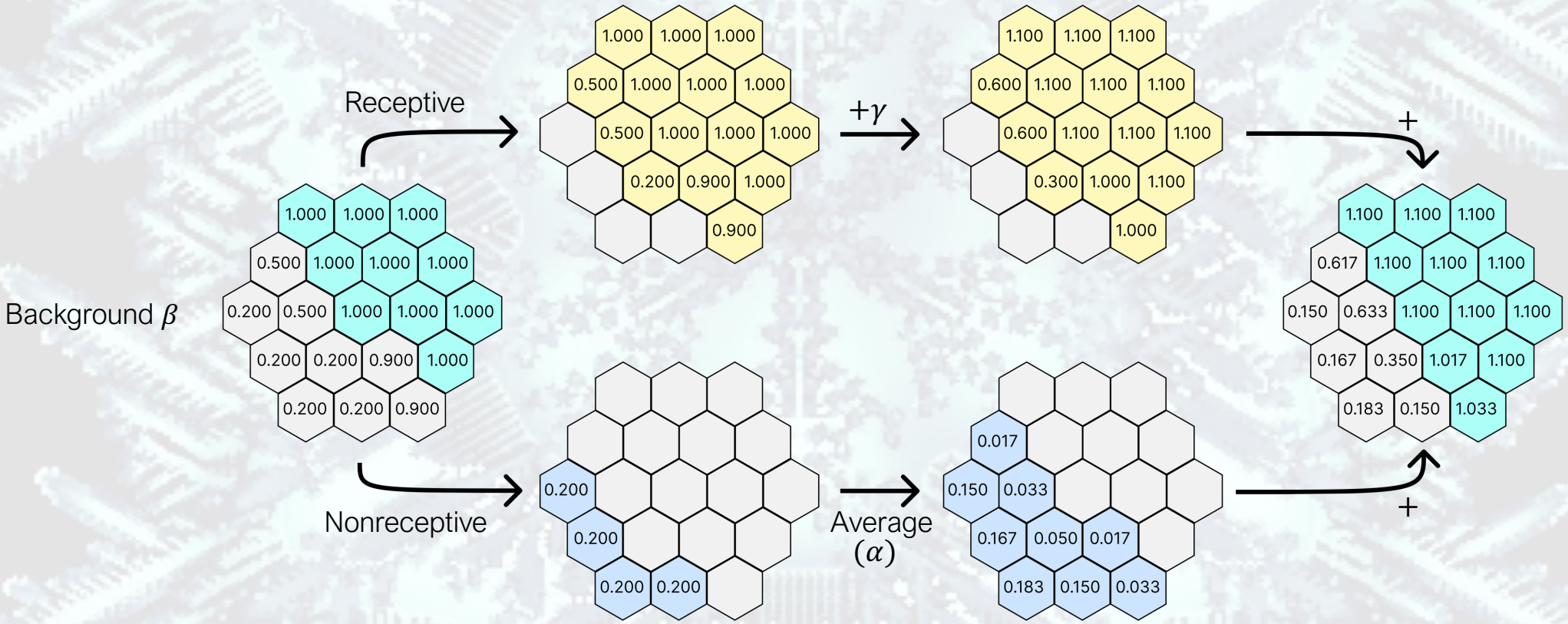
Snow Crystal Growth: Cellular Automata

- Boolean hexagonal automata, starting from a single ice seed surrounded by a sea of homogeneous water background.

- Hexagonal arrangement of cells and each cell contains a real value (amount of water):
  1. Value ≥ 1 → Cell is ice.
  2. Value < 1 → Cell is water (allowed to move).
  3. Value = β → Cell has initial background value (water value).

- The automata has two stages (interaction/behaviour between ice and water):
  1. Receptive cells (ice or with an ice-neighbour) → Add constant (γ).
  2. Nonreceptive cells → Weighted average (α), describes diffusion of the vapor field.

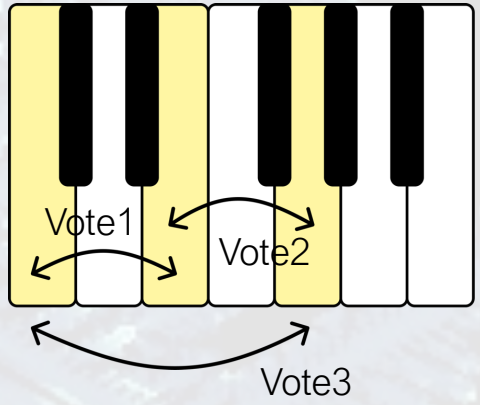
Snow Crystal Growth: Cellular Automata



Snow Crystal Growth: Music Elaboration

- Musical chords (harmony & melody) and tempo of musical phrases are considered.

- How chords are classified & used:
  1. Listen to NoteOn & NoteOff messages.
  2. Classify each interval of the chord in the octave range.
  3. Assign a vote to each interval according to consonance principles [5].
  4. Assign a weight to each interval to consider absolute distance between the notes (for example, a 2nd weights more than a 9th).
  5. Compute weighted average with votes and weights.
  6. Use weighted average to change crystal's growth behaviour.



[5] Trulla L., Di Stefano N., Giuliani A. (2018), *Computational Approach to Musical Consonance and Dissonance,* FIP, https://doi.org/10.3389/fpsyg.2018.00381

Supercollider Regions and Synths

- The Supercollider code has four regions, they are implemented to create:
  1. Midi connections and buffer/array of notes
  2. MIDIdef (Interface for MIDI messages)
  3. SynthDef
  4. OSCdef (Interface for OSC messages)
- Four different SynthDefs are created.
  1. Rhodes Synth
  2. FM Synth
  3. Kalimba Synth
  4. “Super Saw” Synth

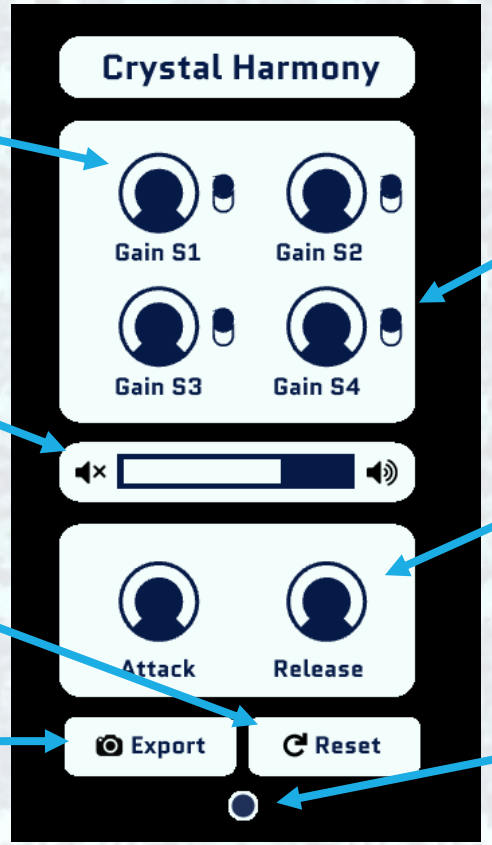
Graphical User Interface

The knobs control the volume of Synths.

The volume slider controls the global volume.

Reset button to make the crystal restart from the seed.

Export button to take a snapshot of the Processing window.



The toggle switches bypass the Synths.

The knobs allow to change the attack and the release of the played sound.

The led shows when the crystal reaches the window boundaries and stops growing.

Limits and Future Developments

- Add stochastic features to take into consideration that nature constantly changes (non-homogenous background).
- Optimise code for slower computers.
- Take into consideration more musical features.
- Implement a 3D snow crystal to recreate all possible shapes that are observed in real life.