Blurry Boundaries: Queries on Boundary Phenomenon by Using Doppler Effect

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Abstract

This study introduces findings and outcomes of an experimental research based on a Doppler-inspired visualization process. Doppler Effect, by definition involving dimensions of time, velocity, direction, space-observer relations and wave provided provided a basis for the initial assumptions of the experiments. The body of a person in a space is considered as a source of doppler wave. The events consisting of movement are defined as the impact area of the event. Physical surfaces are assumed as reflective and nonreflective constraints. Therefore, the way doppler effect is abstracted, while waves are spreading out from a living source, space plays a crucial role to characterize the perceptual aspect. Moreover, theoretical foundations of the experiments were fed from Toyo Ito's flow and blurry architecture concepts. The experiments lead primarily new understandings about the boundary concept. With the aim of expanding the potential meanings and definitions of boundary concept, in order to investigate the changing relations between subject-event-space diagram-based scenarios and rule-based approaches were developed in Processing environment.

1. Introduction

Architecture has always been related with the concept of enclosure and boundary. It can be considered as a mediator that separates 'inside' and 'outside' and establishes the relationship between these two situations. People who inhabits in the environment are being continuously shaped by physical, cultural, and social fictions. Boundaries are the ones that affect relationships of people and environment by separating or surrounding them. Tschumi opposes the idea of reducing architecture

into merely space and form [1]. As event, action or what happens in space are also related to architecture. Especially in the modern era, when the boundary phenomenon has begun to be questioned in Cartesian forms, it has been a controversy in the architectural literature as a phenomenon frequently mentioned. Therefore, Le Corbusier has used the prime geometries as design elements due to their clarity which can be easily perceived, Mies van der Rohe has made architectural planning studies concerning total space search with less restrictive architectural elements, Wright has worked on designs that question internal-external relations. A vast number of studies have been investigated the concepts of transparency, inter-space, massive fluidity, topological and topographical relations.
In this manner, architecture has been attributed to the form, the ending, containment, the building shell or the wall of the room. Concurrently, architectural space has been considered as a void which has nothing in it. However; the perception of people cover multisensory and complex interactions, beyond receiving merely visual stimuli from the space. There are also 'materials' such as air, gas, fire, sound, magnetic effects, light which intentionally or unintentionally fill that void. In his “Blurring Architecture” text, Toyo Ito conceptualizes the elements of “blurry architecture” in three items:

1) The responsive architecture as a designed artificial which takes components of natural environment such as light, water, wind, into account;
2) A room which provides an extent of flexibility to change its program
3) Architecture seeking for transparency and Homogeneity [2].

Toyo Ito approaches the phenomenon of “boundary” in relation with the metaphor of “floating” [2]. According to Ito, human inhabits in nature and society through the experience of/experiencing bodies and the perception of 'inside' and 'outside' over the body can be considered as the floating of water [2]. The body is neither inside nor outside, at the connection point; it can be expressed as "floating" if we fill the void at this connection point. Ito describes this approach as “blurring architecture”[2]. Blurring architecture defines a kind of soft architecture image that does not yet have a definite shape. The physical description of this situation can be achieved by a soft limited architect responding to natural aesthetics (light, water, wind) or by a transparent and homogenous structure suitable for program changes of a space [2].

In physics, the boundary is not a static field, is a layer moving between the two fields. This layer occurs as a result of energy differences which depends on various states such as temperature, pressure, density. Philippe Baylaucq's high-resolution thermal camera shoots (Figure 1) in “ORA” film, can be considered as an example of how to define a gradient interconnection between energy differences in terms of an artistic interpretation[3]. The scenes in the film involve a second layer of gradient colours surrounding the dancers' bodies and the colours form a thermal space informed by synchronously moving dancers in the same area. Sean Lally points out the gradient light of a street lamp in a dark street as an example to boundary state of the energy [4]. As Lally highlight that people feel safe when they enter an area which is restricted by the light, even though there is no physical obstacle. As an experience of this situation, the series of interactive installation 'Transcending Boundaries' by teamLab can be exemplified [5]. The 'Transcending Boundaries' (Figure 2)

installation, by only differentiating the qualities of light, led audience to perceive and question the limit of space.

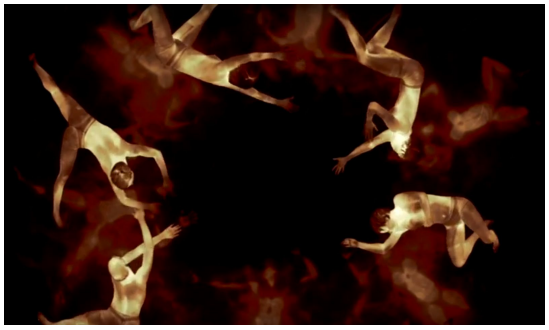


Figure 1: A screenshot from ORA [3]

Figure 2: Event based visualization [5]

The energy change, the flow of the energy and the concept of entropy have been approached by various scholars [2-8]. Beesley emphasizes that current developments in technology may allow to create a completely new built environment typology using thermal, acoustic, chemical and electromagnetic energy [7]. In the context of boundary concept in architecture, Beesley criticizes the conventional assumption of boundary which is reduced into the basic shapes of 'circle or sphere'. He argues that, the conventional assumption of boundary effects the way people perceive and comprehend the space. However, the position of an individual continuously changes, the perception of spatial relations as well. Beesley suggests a form that represents a permeable area surrounding the individual. This form is more of a twisted form that surrounds the world around the individual as a network [8].

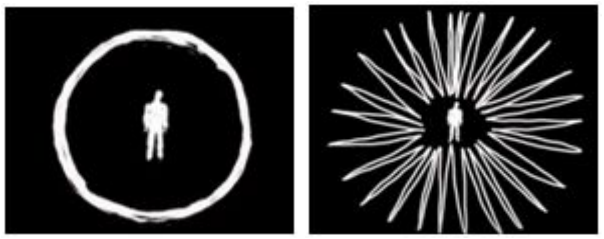


Figure 3: Beesley's boundary descriptions [8].

In 'Earth moves: The furnishing of territories' book, Bernard Cache writes "*Our brain is not the seat of a neuronal cinema that reproduces the world; rather our perception are inscribed on the surface of things as images amongst them*" [9]. The view of our surroundings can be considered as a reflection of our interpretation of them. Therefore, our way of seeing is crucial to the understanding of space, architecture, territories and everything else. This is why Cache concerns about expanding the limits of our understanding of the space. Images could always be read as abstract mathematical elements and relatedly all physical elements can be simplified into pure geometric forms in some extent. For instance, to redefine a landscape, Cache interprets that all the variations of the landscape can be converted into geometric shapes. Further to this assumption, he translates a vector that projects onto an abstract line of the terrain [9]. He draws an inflection in between points (Figure 4).

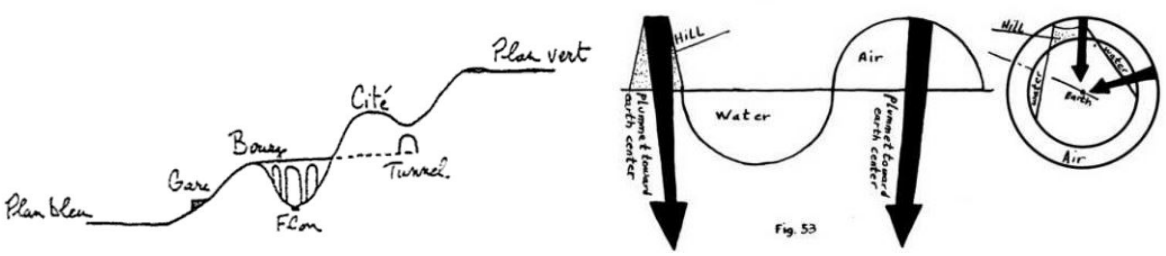


Figure 4: Louve city definition of Bernard Cache [9].
Figure 5: Earth, water and air drawing by Paul Klee [10].

Reading our surroundings without identity allows for the infinite change and creative possibilities that might push potential developments [9]. Accordingly, re-reading the concept of boundary between the self and the space through different modes of abstraction is essential to gain new understanding. Similar to Cache, in 'Pedagogical sketchbook', Paul Klee describes the world, nature, naturalness, everything on earth, water, air, dimensions of human body with moving lines (Figure 5) through a free creation of abstracted forms [10].
In the light of these discussions we argue that investigation of the relationships between body and space in terms of architectural representation which might bring new dimensions to boundary phenomenon. The way one abstracts the ongoing spatial and motion-based relations in the world would be a key action to enrich thought, imagination and the design ideas as well. Therefore, this study aims to introduce a Doppler-inspired interactive boundary visualisation process and discuss the potentials and limitations of the outcomes in the context of their contribution to understanding of boundary concept.

2. Doppler Effect and Boundary Phenomenon

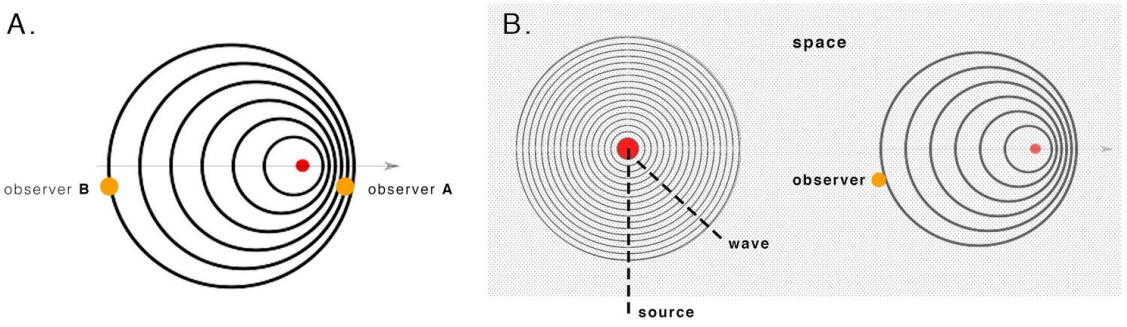


Figure 6a: Doppler effect
Figure 6b: Waves radiating from the source and motion of source

In the scope of this study, the doppler effect has been approached as as initial concept to manifold the affordances of boundary phenomenon. In a broader sense,

the Doppler Effect refers to perception of light and sound signal phenomena which emerges from relationship between the signal source and the observer. By mathematical definition, the signal moves closer is perceived as being higher than it actually is, whereas that same signal moving away will be perceived as being lower (Figure 6a) For the formation of the doppler effect, a signal source in movement, an observer and spatial (space and time) relations between them are required (Figure 6b).

In order to get a better understanding, the components of doppler has been divided into components as a preliminary assumption. These components (i) space, (ii) observer, (iii) wave lead to a parametric ground which can be elaborated in different directions. In other words, during the digitalization process of boundary phenomenon in experiments, the variables and assumptions on doppler effect was used. The doppler effect is considered metaphorically as a spatial agent. The metaphorical consideration of doppler effect allows to explore new the relationships between space and boundary.

2.1 Defining Space in Terms of Its Geometrical Limits

In a broader perspective, the term space conveys the meaning of a place that encapsulates the events. Relatedly, the concept of encapsulation needs to be unfolded in terms of the limit of a space defined by a borderline or a threshold. In the scope of the experimental process, space refers to the physical surfaces encapsulating an event. The digital layers which might augment the notion of space were neglected. Therefore, space is considered as a border line or an obstacle, that does not allow some specific actions to pass through from inside to outside (Figure 7a). To give example, concrete walls of a room which limits the transition of light can be considered as spatial boundary.

Shown in Figure 7a, encapsulating surfaces are taken as in-situ boundaries. Threshold in Figure 7b demonstrates a spatial extension of an event, without having a border. Instead the threshold value which is represented by changing radii values representing the distance from the source of event. Therefore, the threshold value is considered as depth that shows spatial extensions of event. Threshold is determined by range of waves and it extends through spatial extensions of event. In that manner, the depth of threshold demonstrate the areas of all possible actions covered.However there is no any certainty about depth of threshold if it is evaluated as abstract notion. It is a re-definable / re-coded concept/ structure and any decision can be applied on it various contex.

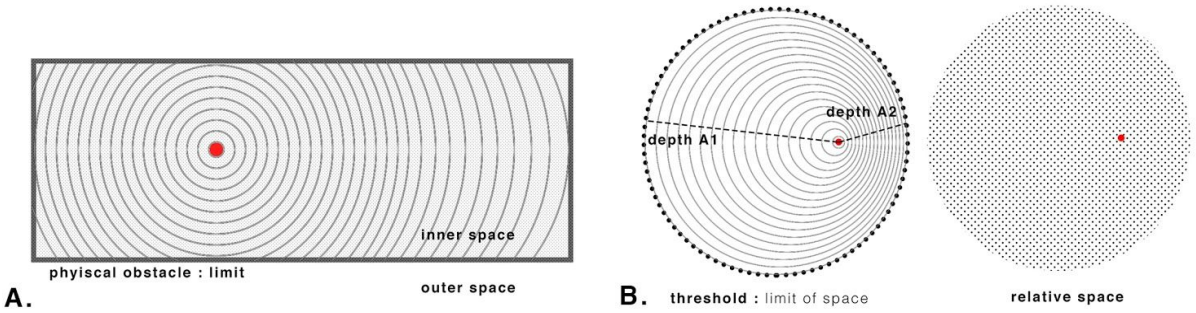


Figure 7a: Space definition in context of obstacle and 7b: Threshold

To exemplify, Sean Lally's street light description can be mentioned [4]. Lally illustrates street lights as light sources illuminating dark[4]. He mentions that lights fall on ground[4]. In that case, ground becomes obstacle or boundary. He adds that the transmission of energy levels high to low can be easily read, between too lightened through darkness there is a threshold that divide space as where is lightened and dark[4]. Another example is shown in Figure 8 regarding the interactions among the bodily event, wave and encapsulating interfaces. When the boundary concept grounded on a real space (where is physical obstacle), that mixture (unity) reveals the interfaces of encounters. A body grounded in public or private space, reading the maps of events inevitably employs the cultural (socio-political and economical) problematics in terms of body and this investigation can turn to cultural study. Surfaces can respond to the waves in different ways. In this study the behavior of the surfaces are limited to :reflective and nonreflective surfaces.

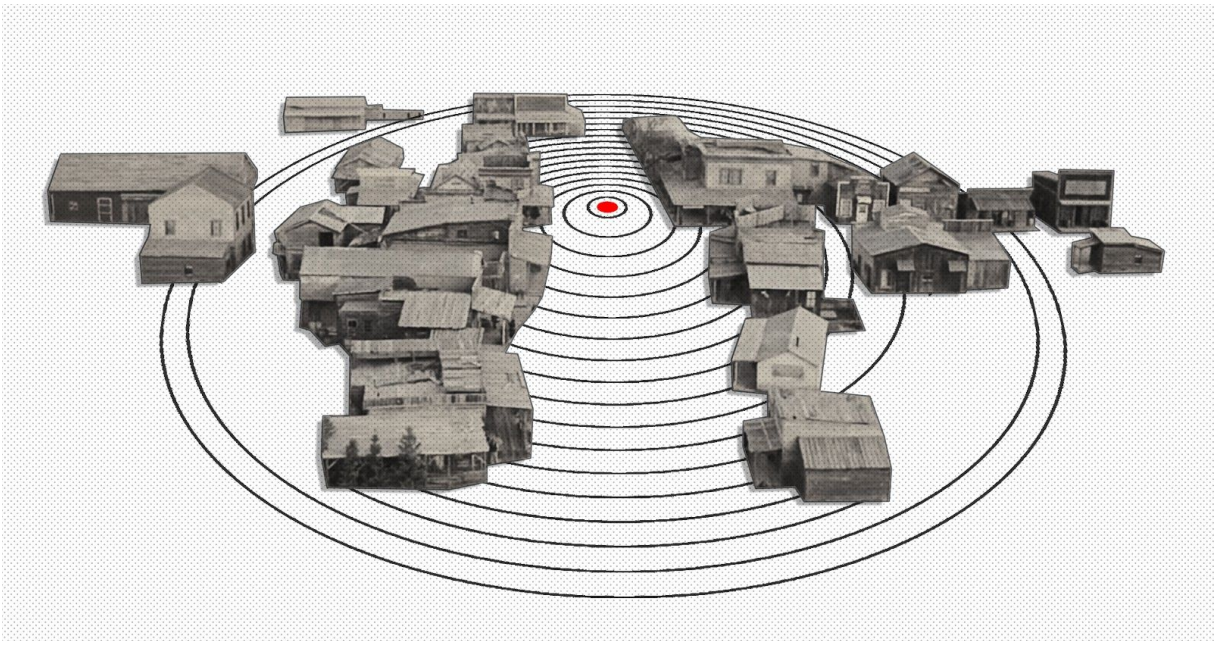
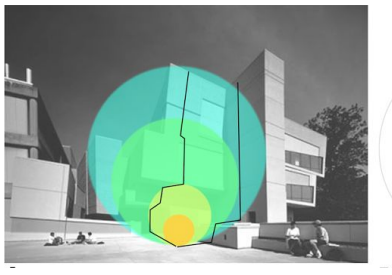


Figure 8: Grounding bodily event in real space

2.2 Sources of wave: The deconstruction of Body

A source of wave is represented as a second component of doppler effect. In the theoretical ground, the source of wave indicates to the body. As it was mentioned in the previous section, the existence of body (itself) inevitably grounds on public and private space within political situations and in the urban scenes, as an example relations between grey/ green areas sizes and mostly everything can easily demonstrate to us how the environment respect to the body. We argue that, the body and the scales play crucial role to broaden the context of that boundary investigation. While body can be noted as the one to generate waves itself, also body parts (like hand, head, feet) can be considered the generator as well. The encounter between the body and physical environment (which are manmade and nature) indicates the sense of scale of the environment in which the events take place. Accordingly, mapping the movements of either one part of the body or taking the human body as a whole provide an opportunity to digitalize relationship between body and space. Today, motion tracking and capture of hand and body movements became not only possible but also feasible by the advances in sensor technology. Different than the existing studies on 2D and 3D visualization of body movement, this study aims to introduce a series of experimentational visualization of body-dependent boundaries in space. Main aspects of Doppler Effect such as observer-source dependency, change in motion, change in direction were inherited.

Apart from those, and different than doppler effect, self-triggered wave generation mechanism is proposed. Within self-triggered wave generation mechanism, as it is shown in Figure 10, further to the intersection of the waves and encapsulating surface, new waves are considered to start. A diagrammatic section-based expression is shown below (Figure 9, Figure 10):



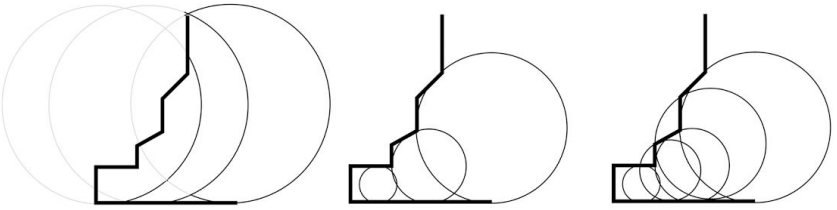


Figure 9: Visualization of doppler as a packing element

Figure 10: Diagrams of section based variations

3. Experimentation

The research of blurry boundaries is conducted by a series of experiments. Experiments are evaluated from basic to complex structure step by step to understand fundamental question how the waves of bodily event possibly behave inside the encapsulated space. In other words, while the human body assumed as a source of wave, how/if changing boundaries of the potential events can be mapped and visualized in different ways. Experiments are performed in terms of space, rules and events specification. Evaluation process of experimentations is stated with diagram based scenario through slow computing and it is finished with implementations.

3.1. Diagram based scenario

Visualization of the doppler effect and exploration the relations was the crucial stage of the experimentation. Diagram-based scenario stage aimed to foster creative ideas and divergent thinking regarding the speculations on the concept of boundary. Photoshop was used as tool for colleges to see fast visual effects, apart from sketching. In this way, analysing the possible opportunities and parameters sets in two scenario. First scenario approaches the notion of doppler effect through shape and colors in terms of visual and formal character. The source of doppler was represented with a point. Based on the assumption of simultaneous execution of different events in a space, multiple doppler sources were used (Figure 11). Further to the initial abstractions, the second scenario focused on real-time interaction and implementation. Body parts were considered as a source of doppler wave and, movement of body assumed as a initiator of doppler waves in 3D space (Figure 12).

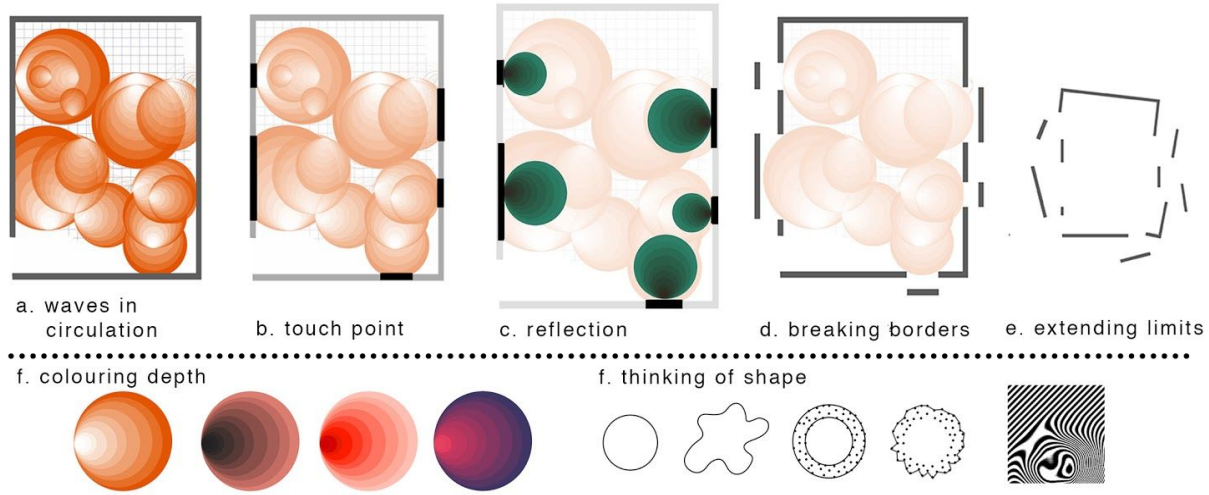


Figure 11: First formed scenario

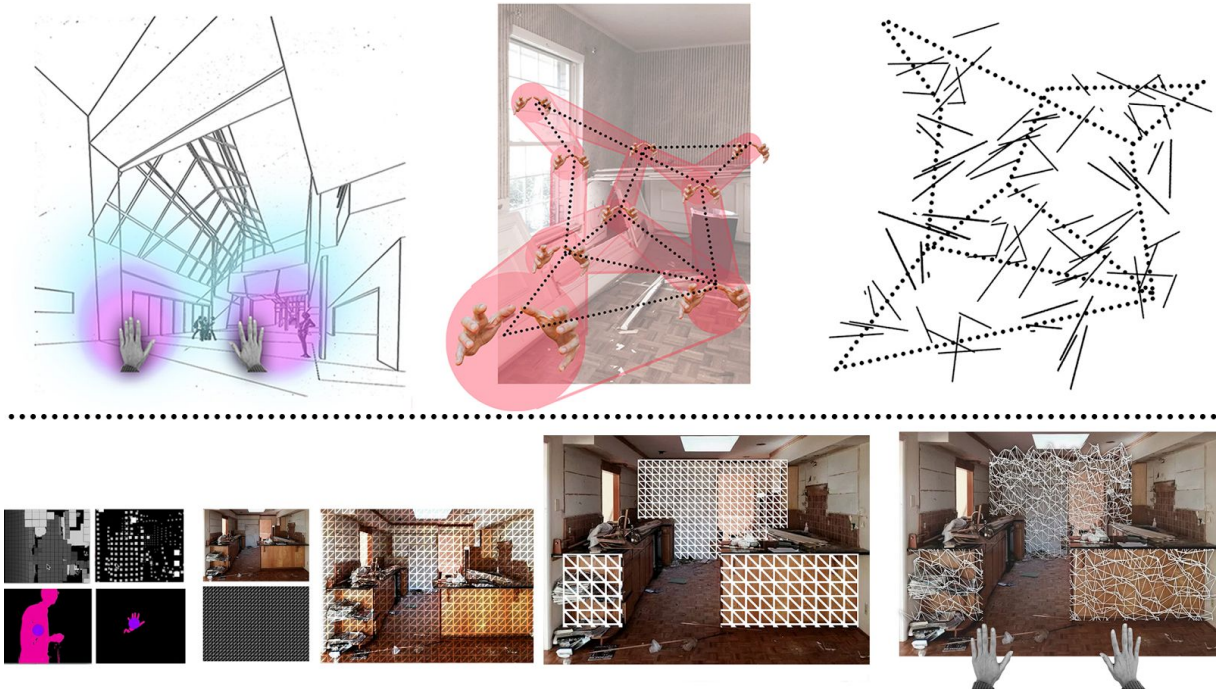


Figure 12: Visualizations for three dimensional space scenario

3.2. Slow Computing

Further to the scenario development, the assumptions on the doppler effect were translated into Processing environment through rules and algorithmic structures. This stage can be considered as a bottom-up process in which each consideration has been converted into programming codes and tested. Instead of focusing on instant and working outcomes in Processing, this process has focused on generation of rules, relations and event specifications.

3.2.1. Space

“Impact area” and “encapsulated space” were the basis of the assumptions for space, as it has been previously explained in section 2.1. Impact area refers to a self-triggered wave generator (body) and the encapsulated space is a boundary which consists of reflective and nonreflective surface layers. In addition, regular shape and indented-irregular shape were examined within form of the encapsulated space.

3.2.2. Rules

Five rules are defined to explore boundary situations in relation with the surface typology of a fictional or real space (Figure 13).

Rule 1 - The first rule involves continuously wave generation. The waves are considered to spread out from a center point towards outside as circles. The period parameter affects the distance between consecutive waves.
Rule 2: Whenever a wave (circle) touches (intersects with) a surface, stop growing.
Rule 3: After Rule 2, shift the center of growth of a wave to the intersection point of the wave and the surface.
Rule 4: Whenever a wave intersects with a surface, generate new centers (center of wave).
Rule 5: Apply perlin noise to the wave. In other words, from a certain distance affect the radii of the impact area.

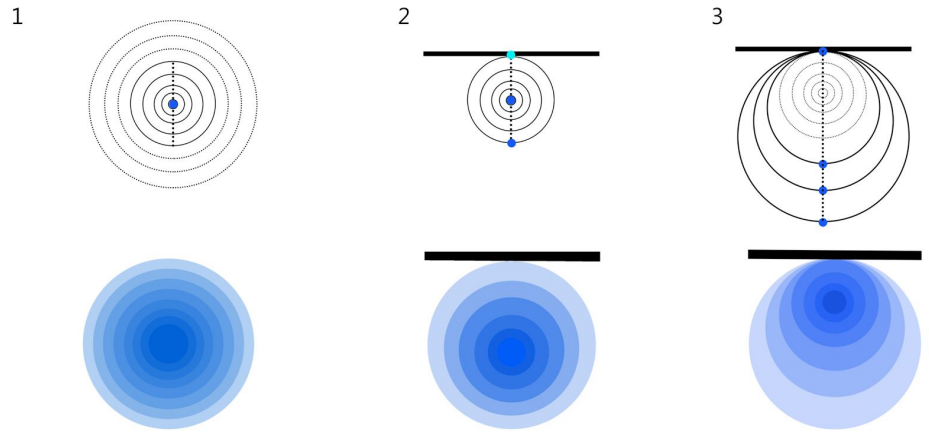


Figure 13: Visualization of the first three rules

3.2.3. Event

Conception of event leads the exploration of the limits of wave diffusion in space. Events involve the movements of the source without having any directional purpose. It is assumed as a continuous motion with a consistent direction with certain paths. In the scope of the experimentation, two paths were examined: Simple/linear path and multiple/connected paths. While the linear path involves simple motion, the multiple/connected path involves more complex potentialities (Figure 14).

3.3 Experiments

In this stage, different visualization techniques were tested to unfold potentials of the experimentation. Circles representing the impact area of the source way, Pink square explores limits of radiuses, Orange square are illustrates both the directions of impact area which is perpendicular to the path and how impact area fills the different levels of voids in space. Touching points of waves on the surfaces are demonstrated with red arrow (Figure 14).

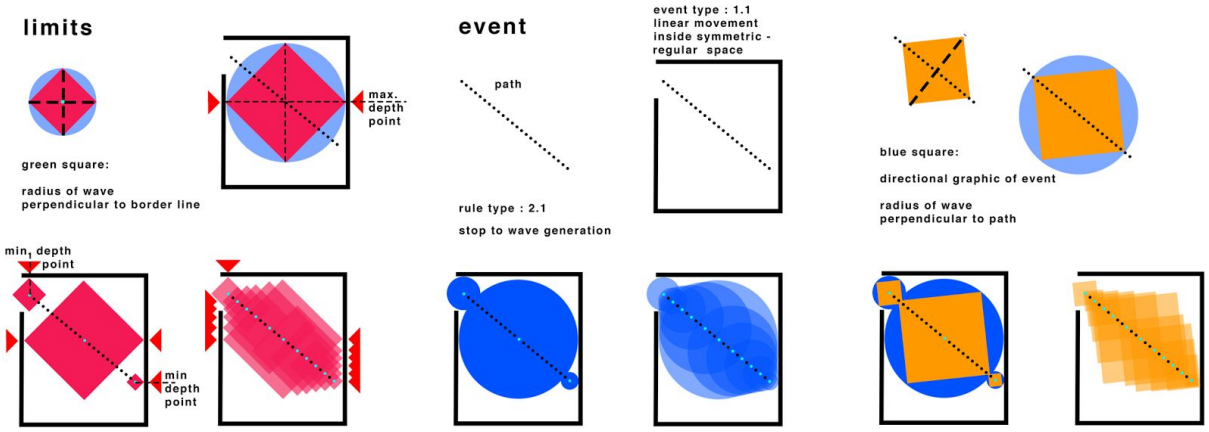


Figure 14: Experiments in defined spaces

3.3.1 Experiment - 1

The first experiment focused on the source of wave which represents the impact area, nonreflective surface and encapsulated regular shape spatial properties, Rule 1 and Rule 2 as an interaction mode and linear path event (Figure 14).

3.3.2 Experiment - 2

This experiment have same specification/ parameters with Experiment-1 yet only difference is choosing the encapsulated irregular space rather than encapsulated irregular space(Figure 15).

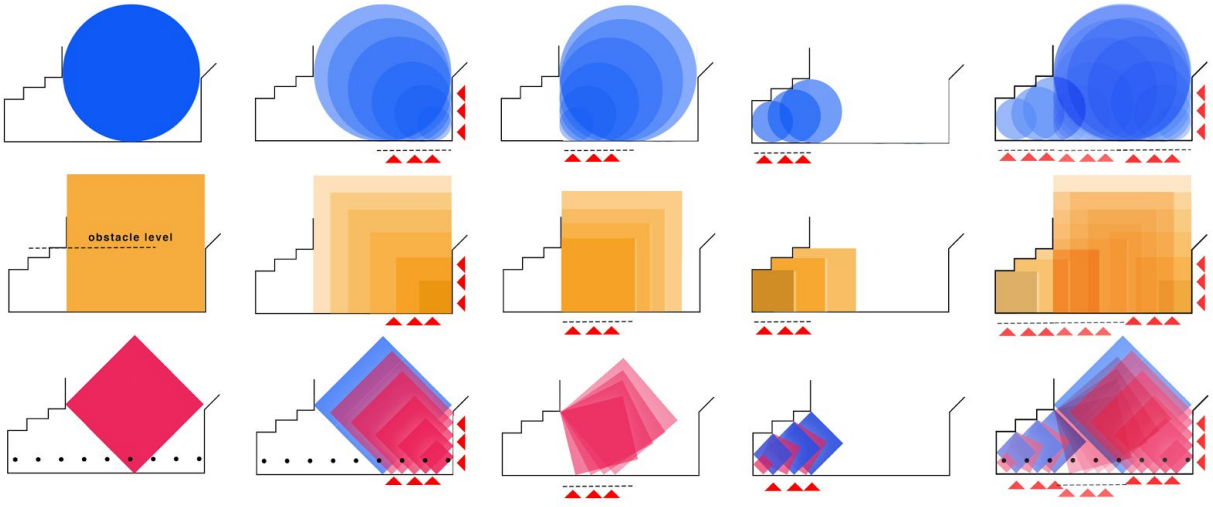


Figure 15: Experiments in irregular formed spaces

3.3.3 Experiment - 3

Further to the bottom-up explorations in Experiment 1 and Experiment 2, Experiment 3 can be considered as a top-down process in which sample programming codes [11] are decoded and adapted to the context of the study. Kinect 360 was used for motion capturing and Processing was used for visualization in Experiment 3. During 2D visualization, kinect camera was used as top view camera. The body was assumed as a dynamic agent and a source of light beam (vector) generator. Real time body-space interactions were mapped onto 2D planar surface. The algorithm schema of the code is shown in Figure 16 below:

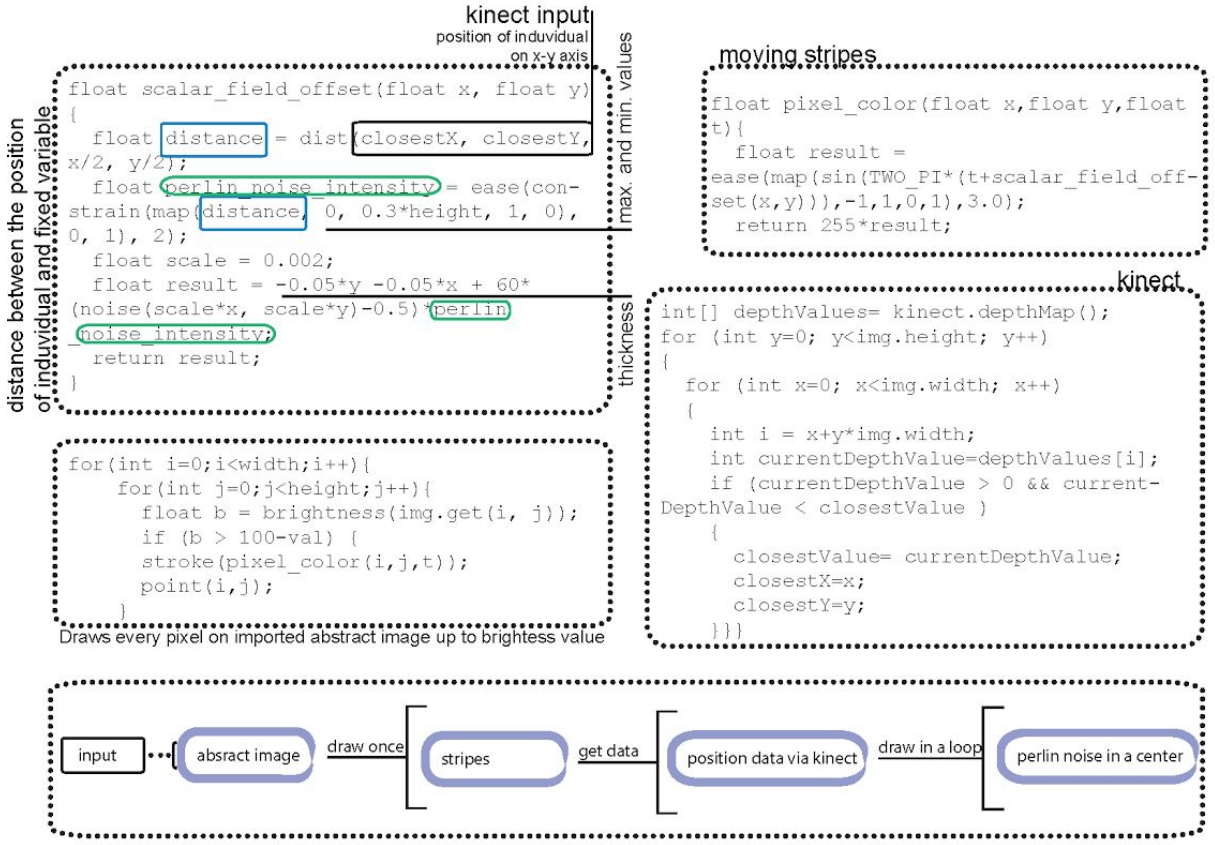


Figure 16: Flow of the program

The variables of the code consist of number of the people, the location (X, Y) of the people, speed of the movement, spatial constraint (encapsulating surface), frequency of the wave (time-depended), stripe value and perlin noise. The time-dependent frequency value is also linked to the speed of the movement. The stripe value refers to the distance between two waves and it is related with the speed. In addition to these variables, perlin noise is used for generating more natural effect on the Processing outcomes. The perlin noise allows an opportunity to restructure doppler waves.

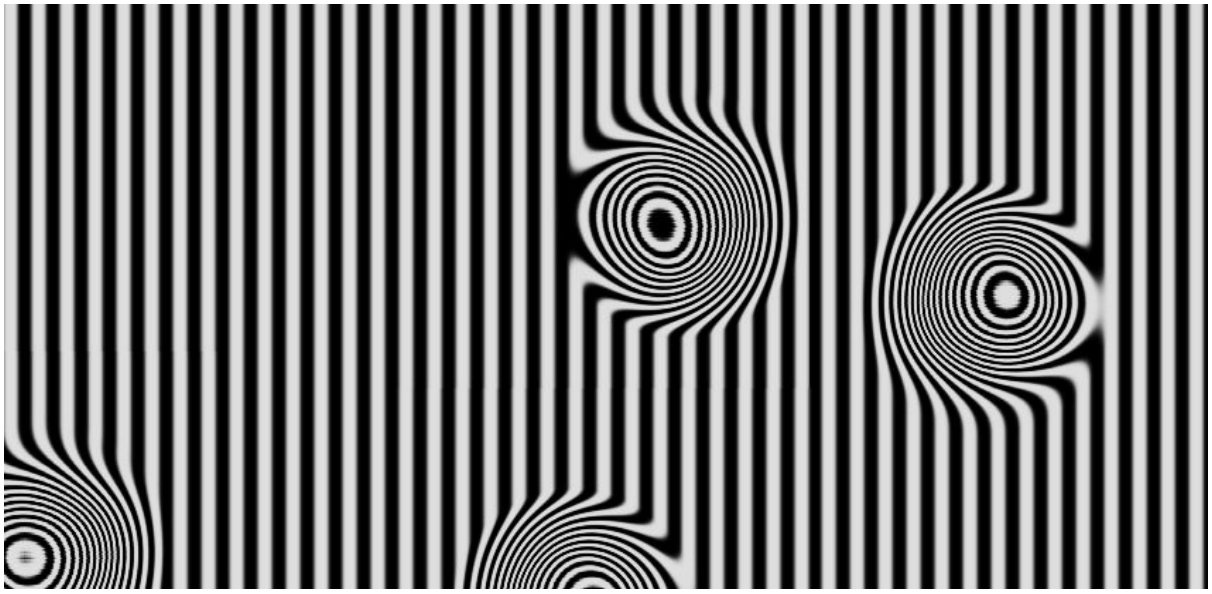


Figure 17: Abstract visualization of motion without any stimulant

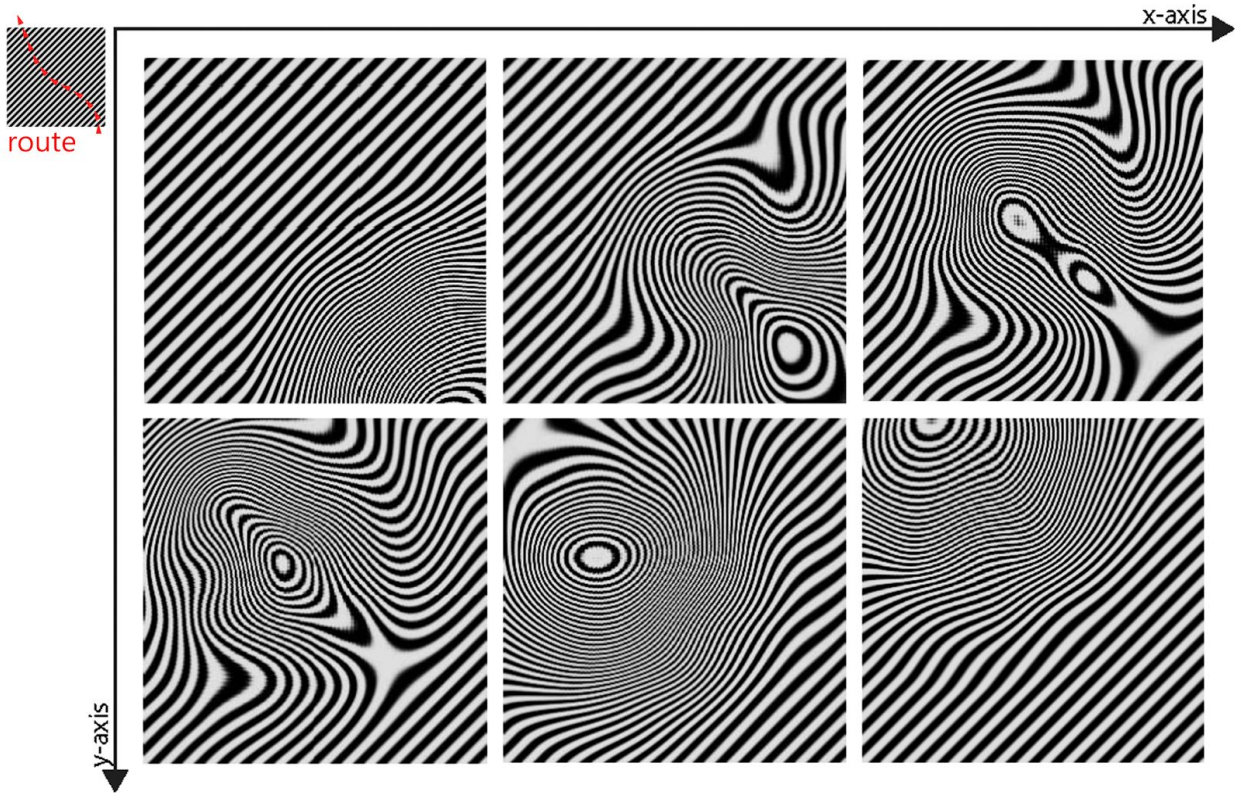


Figure 18: Motion on a route

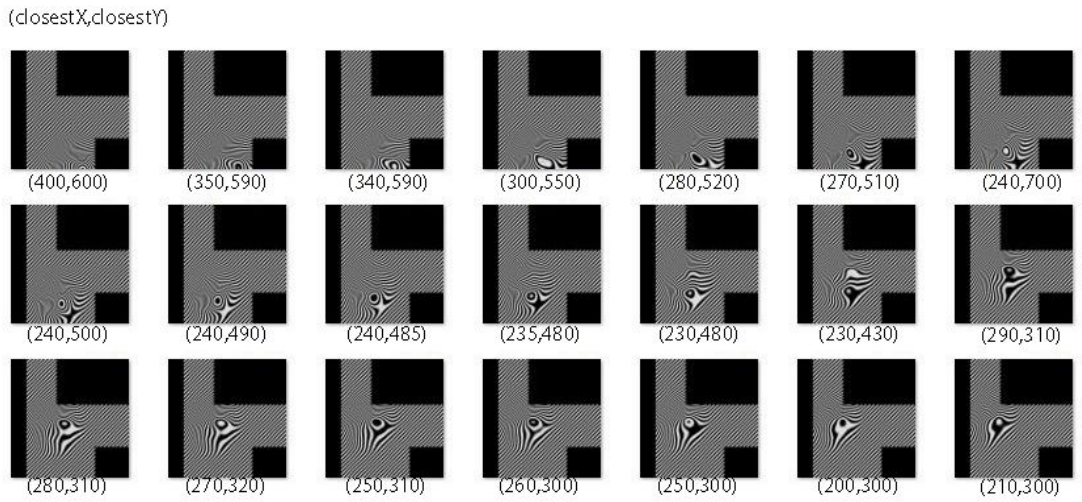


Figure 19: Results on different positions of individual

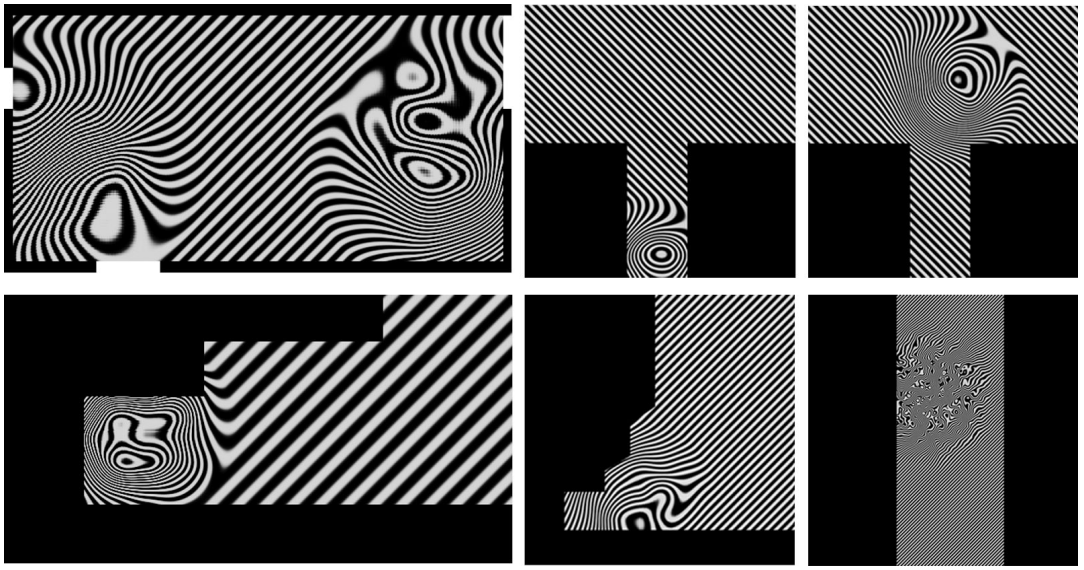


Figure 20:Variations on fitting to space

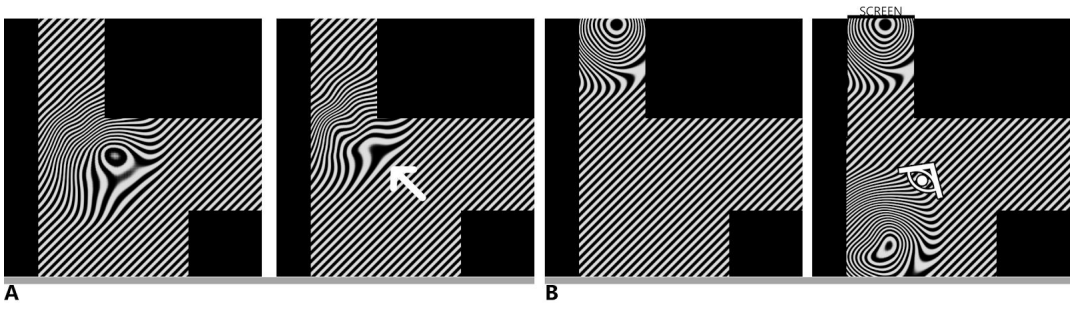


Figure 21a: Change of boundary perception through wind

Figure 21b: Change of boundary perception through an interface

4. Concluding Remarks and Discussion

In this study, mathematical definitions of the doppler effect have been examined as an initial departure point. The concept of boundary, relatedly the changing relations between subject, event and space have been investigated through diagram-based scenarios and a series of visualization experiments in Processing environment. Insights derived from the experiments show that the doppler-inspired approach has potential to be used in generating visuals on:

Impact area: Apart from the representation of body in a closed space through basic geometries (Figure 11), wave-based representation might lead more reflective (Figure 10), reflexive and relationally complex outcomes (Figure 17-21).

Event maps: It is possible to generate different event maps based on real-time or retrospective usage of motion capture data. Therefore, doppler-inspired approach has potentials to achieve blurry traces of the events.

Holistic reading of fragmented/discrete events (Figure 17-21).

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