ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

AN INQUIRY ON FLOW METAPHOR IN THE CONTEXT OF DIGITAL CREATIVITY

M.Sc. THESIS

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DİJİTAL YARATICILIK BAĞLAMINDA AKIŞ METAFORU ÜZERİNE BİR ARAŞTIRMA

YÜKSEK LİSANS TEZİ

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Zeynep BUDAK, a M.Sc. student of ITU Graduate School of Science Engineering and Technology student ID 523121015, successfully defended the thesis entitled "AN INQUIRY ON FLOW METAPHOR IN THE CONTEXT OF DIGITAL CREATIVITY", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To Canan,

FOREWORD

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June 2018 Zeynep BUDAK
(Architect)

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SUMMARY

This thesis investigates a metaphor, flow in terms of interpreting concepts, design and digital creativity. The thresholds of change may be defined more clearly by the representational property of the flows that problematize the undetermined so that dynamic imagery and possibilities can be conceptualized by becoming and transitioning. This study focuses on the qualitative features and conceptual possibilities of forms by breaking down the threshold barrier between virtual and reality, as flows represent the occurrences. Conceptualizations enable dialogue of design, imagination, visualization and perception process with other disciplines. In this context, this thesis is about the representation of flow in computer environment by the means of associating conceptual narratives, creativity and objectivity in design and algorithms.

In this work, firstly, concepts and theories on flow are elaborated. Interpretation of flows, ways of thinking, explorations, networks, concepts derived from flow such as complexity, emergence, multiplicity, smooth and striated spaces and discussions on fuzzy boundaries are defined. The natural processes observed in the context of changing physical states such as energy, magnetism and the mass movements of flocks or communities are described by flow behaviours. Energy flows and equilibrium state are identified by defined or unexpected behaviours of the particles with the thermodynamics definitions triggering the creativity and physics in the context of formation and intellectual debates. In the context of design, the variability of form, the interpretations of design according to visual and relational point of view, the changes in spatial scales, flow dynamics, shaping of flow as energy, boundary definitions, permeable boundaries and points of view on the definition of spaces by flow lines are presented.

In the third chapter, computability of flow concepts is mentioned in the context of discoveries at the intersection of technology and design. By referring to animated forms and simulating the complexity, the interpretation of the motion perception on a single square in the art with the changes of the motion sequences and visual illusions in algorithmic design are discussed. Theories that computational methods are used to describe observable flows, interpretations of mathematical explanation of flow and methods based on the working principles of simulation programs are expressed. An overview of transformational properties that the algorithmic logic uses in the representation of natural processes is pointed out and examples of the productivity of these variables are given. In parallel with the developments in technology, representations of flow in artworks and evaluations on creative experiences are presented.

Interpretation of flow concepts as metaphors and definitions together with flow conditions in the real sense lead to a process in which design possibilities are dynamically processed. Technology in a continuous regulation and repetition also produces its own nature and phenomena in its own developmental process. This

phenomenological structure of the digital leads design to new perspectives which may be an intertwined way to bring together virtual and actual in a digital reality. The repertoire of scientific knowledge requires a new repertoire of knowledge production analysis that reconfigures process, experimentation and observation.

In the fourth chapter, abstract digital flow experiments are presented with flow concepts to investigate the potential of conceptual and phenomenological properties of the flow. The flow metaphor of the production processes of algorithms and simulations produced in the digital environment were investigated in order to base a behavioural basis on how to visualize a non-mechanical motion in the digital environment during the design processes. The experiments were carried out to analyze algorithmic concepts and abstractions with animated series to investigate the potential of algorithms. Analyzes on motion and transformation depending on time were made to explore the productivity of concepts diversified by the adaptive nature of computation.

As a result, the predefined processes of design, interpretation and heuristic attempts do not happen in a completely fixed or structured world. Within the productivity of algorithms, the design process may produce unexpected processes and outcomes. Unlike traditional design, the uncertainty-driven concepts can lead to the creation of new ways of thinking and evaluations in algorithmic design. Algorithmic logic feeds on the discoveries and dialogue with other disciplines within the context of virtualization so that expansion of the realizations towards the unexpected configurational transformations represented by the computing environment can improve the creativity of the designers.

DİJİTAL YARATICILIK BAĞLAMINDA AKIŞ METAFORU ÜZERİNE BİR ARAŞTIRMA

ÖZET

Bu tez, kavramları, tasarımı ve dijital yaratıcılığı yorumlamak bağlamında bir metaforu, akışı ele almaktadır. Gerçeklerin değişim eşikleri, akışların henüz belirlenmemişi temsil edebilme özelliğiyle daha net tanımlanabilir ve böylece, dinamik imgelerle imkanlar, olasılıklar, bir durumu terkedip başka bir duruma geçişin ve bu durumun koşullarının tanımı kavramsallaştırılabilir. Akışların oluşları temsil edişi ve dünyadaki her şeyin her an oluş halindeliği bağlamında bu çalışma, bir sonuç ürün üretimine odaklanmaktansa, sanal ile gerçek arasındaki eşik bariyerini yıkmak ile formların nitel özellikleri ve kavramsal olasılıkları üzerine odaklanmaktadır. Kavramsallaştırmalar, tasarımın anlatımı, düşüncesi, görselleştirilmesi ve algılanması süreçlerinde diğer disiplinlerle diyaloğa olanak sağlar. Bu kapsamlarda bu tez, akışın kavramsal anlatımları, yaratıcılık ve nesnel olarak tasarımın ilişkilendirilebilmesi ve algoritmalalarla akışın bilgisayar ortamında temsili üzerinedir.

Bu çalışmada ilk olarak, akış üzerine olan kavramlar/yaklaşımlar incelenmiştir. Akışın yorumlanması, akışı irdeleyen düşünce biçimleri, düşünsel bağlamda ilişki ağları, karmaşıklık, belirme, çoğulluk gibi akıştan türeyen kavramlar ile akış halindeki mekan tanımlamaları, yumuşak ve çizgili mekanlar, bulanık sınırlar üzerine söylemler üzerinde durulmuştur. Bu kavramların görsel temsillerinin, kavramsal formlar ve matematiksel tanımlamalar üzerinden açıklanmalarına değinilmiştir. Fiziksel mekanlar ve ağların oluşturduğu mekanlara değinilerek, bilgi akışının bulanıklaştırdığı mekan algısı bahsi geçen kavramlar ve görsel tanımlamalarla ifade edilmiştir. Kavramlara ilişkin ikinci bölümde, akışın gözlemlenebilir bir olgu olarak okunduğu doğal süreçlere yer verilmiş, enerji değişimleri, manyetizim gibi değişken fiziksel durumlar bağlamında akma davranışı gözlemlenebilen doğal süreçler ile sürüler ya da toplulukların kitlesel/bütünsel hareketleri, geniş alanlardaki hareketler üzerine gözlemler ve değerlendirmeler sunulmuştur. Enerji değişimleri ve denge durumu üzerinde durulmuş, akışın matematiksel tanımlamaları, düzensizlik ve karmaşıklık kavramları üzerinden akışlar incelenmiştir. Sistemleri oluşturan parçacıkların tanımlanmış ya da beklenmeyen davranışları, termodinamiğin yaratıcılığı tetikleyen açık sistem tanımlamaları, oluşlar üzerine fizik bilimi bağlamında ve düşünsel tartışmalarına yer verilmiştir. Kavramlar bölümünde son olarak, tasarım bağlamında akış ele alınırken formun değişebilirliği, görsel ve ilişkisel bakış açısına göre tasarımdaki yorumlanmaları, alansal ölçeklerde değişimler, akış dinamikleri, akışın enerji olarak biçimlendirilmesi, sınır tanımlamaları, geçirgen sınırlar ve mekanların akış çizgileriyle tanımlanması üzerine bakış açıları irdelenmiştir. Tasarım akışları ve karmaşıklıkları tarifleme süreçlerinde, bilgi modelleri oluşturma ve çok katmanlı süreçleri yönetme araçlarına artık sahiptir. Mimarinin bitişi temsil eden sınır tanımlamasının aksine, fizikte statik bir alan olmayan, iki bölge arasındaki hareket halinde olan bir alan, bir katman olan ve enerji farklılıklarıyla değişken durumlar sonucu oluşturulan mekan tanımlamaları üzerinde durulmuştur. Gerçekte kalınlıkları olmayan soyut birer çizgi ve ortamda var olan görülmez dahi olsa malzemelerin

varlığıyla birebir ilişkili bir arakesit örnekleri üzerinde durularak gerçekte ayırandan çok, ilişkilerin ve farklılıkların oluşturduğu dinamik alan tanımlamaları yapılmıştır.

Çalışmanın üçüncü bölümünde, dijital tasarım süreçlerinde, tasarımın önceden tanımlanamayan süreçlerinin bilgisayar ve tasarımcı arasındaki bir dile bağlı olan ve kurallara dayalı olmak zorunda oluşu ele alınıp detaylandırılmıştır. Teknoloji ve tasarımın kesişimindeki keşifler bağlamında akış kavramının hesaplanabilirliği tartışılmıştır. Bu tartışma, akışların anime edilen formlar, veri değişimleri ve karmaşıklığın simülasyonu bağlamlarında yapılmıştır. Algoritmik tasarımın animasyona elverişli yapısı, hareket etme algısının sanatta tek bir karede denenmesi üzerine yorumlar, çizim dizileri ve görsel yanılsamayla hareket tanımlamaları çalışmaları üzerinden değişme üzerine yorumlamalar yapılmıştır. Karmaşıklığın simülasyonu başlığı altında, hesaplamalı yöntemlerin gözlemlenebilir akışları tanımlamak için ürettiği davranışsal teoriler, akışın matematiksel açıklanması yorumlamaları ve simülasyon programlarının çalışma prensiplerinin temeli olan yöntemler üzerinde durulmuştur. Daha sonra, algoritmaların temel özelliklerine geniş çerçeveden bakan bir bakış açışıyla, yaratıcılığa olanak tanıyan yönleri üzerine yorumlamalar yapılmıştır. Algoritmik mantığın doğal süreçleri temsilinde yorumladığı kuvvetler, raslantısallık ve dönüştürme özelliklerine genel bir bakış açısı sunulmuş, bu değişkenlerin üretkenlikleri üzerine örnekler verilmiştir. Bu bölümde son olarak, öznellik ve nesnellik arasında akışın kavramsallaştırılması bağlamında, teknolojideki gelişmelere paralel olarak, sanat eserlerinde akışı yorumlayan çalışmalar sunulup, yaratıcı deneyimler üzerine değerlendirmeler yapılmıştır.

Metafor olarak akış kavramlarının yorumlanması ve reel anlamda akış koşullarıyla birlikte tanımlanması, tasarım olasılıklarını dinamik olarak işlendiği bir süreci doğurur. Bilimsel nesnelerin sürekli olarak bir araya gelme, düzenlenme ve tekrarlanma sürecinde teknik olarak üretip, gerçekleştirmesi bakış açısı bağlamında teknoloji de kendi gelişimi sürecinde kendi doğasını ve fenomenlerini üretir. Dijitalin bu fenomenolojik yapısı, yeni yorumlamalar ve bakış açılarını doğurur. Sanal ve gerçek, dijital gerçekliği bir araya getirmek için iç içe geçmiş durumdadır. Bilimsel bilginin hiç bitmeyen yeniden yapılanma ve düzenlenme süreci, deney ve gözlemi birleştiren yeni bir bilgi üretim analizi repertuarını gerektirmektedir. Bu durum bilimsel olayların tümünün doğadan alınmak zorunda olunmadığı, tekniğin fenomen ürettiği bir dönüşüm sürecinin habercisidir. Yani artık teknoloji kendi doğasını üretmektedir.

Dördüncü bölümde, akışın kavramsal ve fenomenolojik özelliklerinin potansiyellerini araştırmak için, akışa ait kavramlar altında soyut dijital akış denemeleri sunulmuştur. İlgili kavramların başlıkları altında, algoritma ve simülasyonlar ile dijital ortamda üretilen iki ve üç boyutlu görüntülerin üretim süreçleriyle akış metaforu, tasarım sürecinde dijital ortamında mekanik olmayan bir hareket anlayışının nasıl üretilebileceğini araştırması suretiyle davranışsal bir temele dayandırılmak için araştırılmıştır. Algoritmik soyutlamalar, animasyonlu seriler, sürecin gelişimini tam olarak koruyabilmek, algoritmaların potansiyelini araştırmak, zamana bağlı olarak hareket ve dönüşüm kavramlarını analiz etmek için model deneyleri gerçekleştirilmiş ve bu hareketlerden türeyebilecek deneysel araştırmalar üzerinde çalışılmıştır. Kavramların üretkenliği ise hesaplamanın uyarlanabilir yapısı ile çeşitlendirilmiştir.

Sonuç olarak, tasarım yapma yorumlama ve sezgisel kalkışmalar gibi önceden tanımlanamayan süreçler içerir ve tamamen sabit veya yapılandırılmış bir dünyada gerçekleşmez. Algoritmaların üretkenliği içinde tasarım süreci beklenmedik süreç ve sonuçlar üretebilmektedir. Algoritmik tasarımın sonuçtan ziyade süreç odaklı ve geleneksel tasarım süreçlerinden farklı olarak, kavramların belirsizliği ile beslenen yapısı yeni düşünme ve değerlendirme biçimlerinin yaratılmasına yol açabilir. Bir anlamda, algoritmik mantık tasarım olasılıklarınıın keşiflerini besler. Gerçekleştirme sürecinde sanallaştırma, tasarım anlatısı, düşünme, görselleştirme ve algı bağlamında diğer disiplinlerle diyaloga olanak verebilir. Gerçekleşmeleri hesaplama ortamı tarafından temsil edilen beklenmedik konfigüratif dönüşümlere doğru genişletmek tasarımcıların yorumunu geliştirebilir.

Kesin tanımlama ve kısıtlamaları sonlanarak, kavramları genişletmek ve sınırları reddetmek üzerine düşünerek, tasarım tanımlamalar üzerine değil, daha önce adlandırılmamış melezleşmeler üzerine olmalıdır. İlham veren dijital teknikler yoluyla tasarım, belirsizlik, değişkenlik, eksiklik gibi büyüme koşullarını manipüle edebilen yaklaşımlarla düşünülmelidir. Bu bağlamda, sahip olunan yeni algılama ve soyutlama biçimleri, düşünce, hayal gücü ve tasarım fikirlerini zenginleştirme potansiyeline sahip olacaktır. Mimari tasarımın, soyutlama ve metafor yoluyla temsiller üzerinden yeni ürünler üreten doğası düşünüldüğünde, bu tezde yapılmaya çalışılan soyutlamalar tasarım düşüncelerinin evrilebileceği yönü temsil edebilir. Bu çerçevede, doğada, bilimde, sanatta ve düşünsel bağlamda akış kavramları göz önünde bulundurularak üretilen temsillerin dijital üreticilerine yeni işlevler eklenerek, temsil alanının idealize edilmiş yaklaşımlarının özgürleştirilmesi amaçlanmıştır. Çalışma akışları hem tasarım objesi hem de yaratıcılığa katkı sağlayan bir kavram olarak yorumlama yolu ile tasarım düşüncesine katkıda bulunmayı amaçlamış, bu hedefle sanal ve gerçek arasındaki eşik engelini sorgulamaya çalışmıştır.

1. INTRODUCTION

As a medium of expression, using computer to explain philosophical theories is a novel attempt to explore digital phenomena within explanation, observation, or interpretation. Concepts such as chaos, complexity, emergence, interaction, infinity are intellectual and practical attempts closely related to today's design world. the reason behind bringing these concepts to focus may depend on exploration of previously incomprehensible ideas of the human mind through computers. The complexity of nature has now begun to be a perfected source.

Digitalization or encoding of design presents a method which reexpresses itself when the code is translated each time. The translation of an idea to another digital software or media creates new perceptions and unforeseen opportunities. Variation of viewpoints brings many resembled concept about in a cognitive manner. When compared with the period of study with analogue methods; the diversity of viewpoints, the clearer identifications and analysis have made the understanding of complex phenomena clearer and thus designers can advance and analyze possible solutions with more pure perspectives.

Figure 1.1: Nicolas Evans-Cato painting (Leski, 2015, p.90).

In *The Storm of Creativity,* Kyna Leski (2015) mentions Nicholas Evans-Cato, a painter. The painter sees an actual explosion after drawing the tree above (Figure 1.1) which makes him realize that a tree is also an explosion. Surely, explosions happen within a period that can be observed. However, a tree's explosion is not observable since it happens very slowly. Another issue is the change in perception over events which carefully observed. When drawing the tree again, this time the painter investigates the geometry of the explosion so that he gains a new and different perspective (Figure 1.2). Similarly, the goal of this thesis is to explore the flow metaphor as an input to the design processes, similar to looking at the explosion to draw a tree.

Figure 1.2: Tree and explosion (Leski, 2015, p.90).

2. CONCEPTS AND THEORIES ON FLOW

This chapter presents an overview of the engagement of flow concept in the context of the interpretation in an intellectual, observable, physical and architectural view. In each approach, the discourses on flow concept that may be a novel point of view for digital creativity are discussed.

2.1 Flow as a Metaphor and Related Concepts

> Thinking is not innate, but must be engendered in thought.(…)The problem is not to direct or methodologically apply a thought which preexists in principle and in nature but to bring into being that which does not yet exist (there is no other work, all the rest is arbitrary, mere decoration). To think is to create—there is no other creation (Deleuze, 1995, p.185).

The notion of *flow* has been contemplated in various meanings and discourses over time along with nature and movements. In the 1970s, theorists started to relate flows to both physical movements and virtual transformations in time. That revealing tendency was a new comprehension towards the notion of flow. The chaotic nature and, in a way, the uncontrollable character of flows shifted the attention to evolutionary of nature, becoming and process.

Thinkings, texts, paintings, films, buildings are only not the “sites” of knowledge. These forms of expressions are processes of emerging thoughts, concepts, new linkages. Through them, unexpected new connections and transformations are produced. This process can be described as essentially moving, “nomadological” or “rhizomatic.” (Grosz, 2001)

> Conjugate deterritorialized flows. Follow the plants; you start by delimiting a first line consisting of circles of convergence around successive singularities; then you see whether inside that line new circles of convergence establish themselves, with new points located outside the limits and in other directions. Write, form a rhizome, increase your territory by deterritorialization, extend the line of flight to the point where it becomes an abstract machine covering the entire plane of consistency (Deleuze & Guattari, 1987, p.11).

Deleuze and Guattari see concepts as rhizomes, biological entities having innate unique features. Concepts are spatially representable and that representation actualizes with connections and heterogeneity which are characteristics of the rhizomes. Spatial representation of concepts ensures to represent complex multiplicities and has the potential to free a concept from foundationalism via comprehending conceptual relations in terms of space and shapes. Unlike the properties of rooted, centralized, hierarchic, linear arborescent connections, rhizomic structures are composed of heterogenic unifications, multi-centred connections, process, movement, in-betweenness, transforming itself.

> "A multiplicity has neither subject nor object, only determinations, magnitudes, and dimensions that cannot increase in number without the multiplicity changing in nature" (Deleuze & Guattari, 1987, p.8).

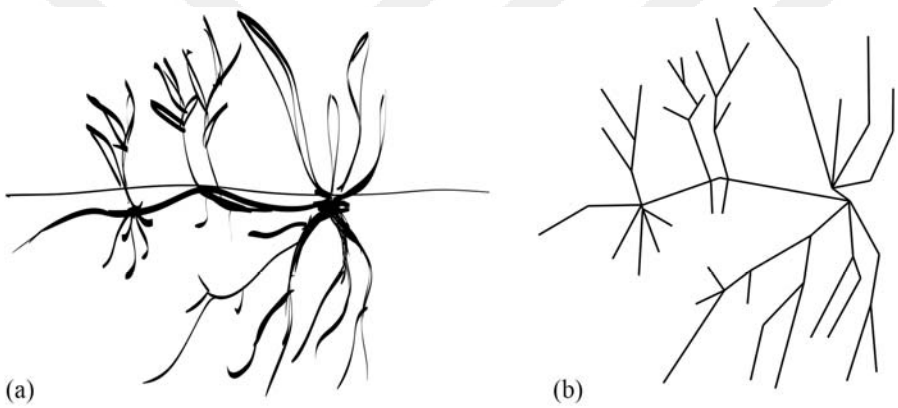


Figure 2.1: (a) A rhizomic plant, (b) the abstraction of the rhizome.

Causatively, *rhizome* is a significant concept due to being a description of the new emergent space. In abstract terms, emergence is defined as differentiation, exposing and extending itself into the world and by intertwining many intensity different emergencies, complexity consists. Fluid structures are susceptible to external effects and obstacles, this makes them have more creative potential that could emerge. Thus, fluid joints that are not specified by linear and static structures. They are identified by liquid evaluations, (therefore) infinite bifurcations, collective identifications from numerous points and perspectives with infinite variations (Figure 2.1).

In his *Philosophy and Simulation*, DeLanda criticizes the philosophy in the early twentieth century, which identifies emergence as something "intrinsically unexplainable". The early emergentists could not conceive the concept of emergence "more complex than a linear clockwork mechanism". However, many nonlinear physical mechanisms exist, and possibility spaces of emergence can be defined by using the consequences of both mathematical analysis and computer simulations. Simulations present interplays between virtual existences with their properties, proclivities, and capacities emerge. In many computers, this emergence can be repeated and be investigated by different scientists as if it were "a laboratory phenomenon". In a like manner of Deleuze, DeLanda describes concepts of the virtual/actual in scientific means and with the term "complexity" and "non-linear dynamics". On this subject, DeLanda exemplifies the energy flow between two water containers which has different temperatures. The flow of energy continues as long as the difference in temperature persists. He defines the rate of changes in the intensity of temperature (similarly "pressure, density, and other intensive properties of molecular populations.") as *gradients.* According to DeLanda (2010):

> In addition to serving as energy sources gradients can serve to generate the moving parts of larger wholes. For example, if a gradient is intense enough and if it is prevented from dissipating it can cause a molecular population to self-organize into a circular motion pattern that will persist as long as the gradient persists. The coordinated movement of billions of molecules needed to yield such a pattern is a highly unlikely event and yet it occurs spontaneously in the ocean and the atmosphere every single day. This coherent circulatory flow, referred to as a convection cell, is produced by the gradient as the means to cancel itself even as the imposed constraints prevent it from doing so (p.9).

These gradient aggregations can be defined as changing and transforming spaces. In this context, Deleuze and Guattari's (1987) description of the space can be mentioned: the "smooth and striated" spaces. The smooth space is an undivided and unmeasured space. The striated space is divided into sections with vertical and horizontal lines according to some standards. To describe these two constantly interconnected places in a simple way, "the fabric and felt" example can be given. The woven fabric is made up of vertical and horizontal elements and has a top and a bottom, as like inner and outer surface. On the other hand, the felt has entangled fibres and cannot be separated from one another by yarns. The felt can be conceptualized as a smooth space. In principle, It is not homogeneous, has no bottom, top or centre. On the contrary, it is "an infinite, open, and unlimited in every direction" (pp.475-476).

> Smooth space is filled by events or haecceities, far more than by formed and perceived things. It is a space of effects, more than one of properties. (…) Perception in it is based on symptoms and evaluations rather than measures and properties.That is why smooth space is occupied by

intensities, wind and noise, forces, and sonorous and tactile qualities, as in the desert, steppe, or ice (Deleuze & Guattari, 1987, p.479).

A strong example of the intertwining of these two spaces can be specified through the paintings of William Turner. Turner's paintings cannot be seen in a single form. If it is neglected the real relationships of the objects seen in the pictures, the image transformations that are solved and scattered by the light effect can be seen (Figure 2.2). Even if putting aside the strong definition of intertwined "everything", in reality, the ocean, sky, desert tend to become a horizon due to the movements. If this complexity is treated as a smooth space, the movements of "things, or ships" in these spaces, take place in the striated space.Whether it is smooth or striated, it is a fusion area of all kinds of space forces so that within the spaces a movement can be initiated that will cause them to be otherwise. As Bernard Cache says (1995), cities are striated spaces. However, it is also possible to establish a smooth space that creates its own dynamism.

Figure 2.2: Snowstorm, Turner (Url-1).

Refrain concept is also a creative operation, a rhythmic regularity, an order that is brought to chaos. It is a line of flight to outside as like the movements of birds. The rhythm creates *milieus* which are "block(s) of spacetime constituted by the periodic repetition of the component" (Deleuze & Guattari 1987, p.313). At this point, it is important to remember the representation of concepts as a body, a line of flight, an act of territorialisation or deterritorialisation and the concept of rhizome represents a flow where there is no certain boundary (Figure 2.3).

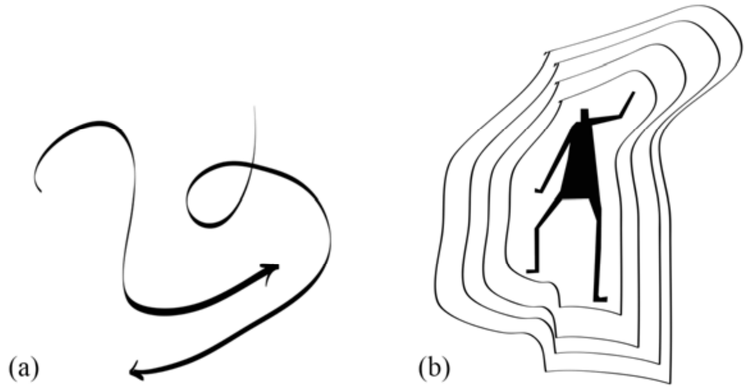


Figure 2.3: (a) Line of flight, (b) milieu.

Multiplicity as a characteristic of rhizomic concepts can also be translated as manifolds, the topological term. Multiplicities as manifolds lead our thoughts to creative, potentially critical representations and a virtually unlimited number of things in geometric terms (Figure 2.4). Rhizomes are connected by the multiplicity of forces and of movements, with becoming, intensities and forces. “the exterior”, “the surface”, or “the outside” is what both enables and resists the movement of territorialization and deterritorialization, in a way, “there is no outside” (Grosz, 2001, p.64).

Figure 2.4: Multiplicities.

In mathematical terms, *manifolds* are is a specific type of topological spaces. In topology, a doughnut and a coffee mug can be classified as “the same,” because each contains a single surface and a single hole. Describing shapes and considering unchanging features of shapes when they turn into another shape resemble rhizomatic thinking. As an example of a nonorientable surface, the Möbius strip has paths such that when the vector comes back to the original point, it is oriented in the opposite direction to the way that it started out. Obviously, there is no inside and outside for the shape. The Klein bottle also has the same nonorientable surface (Figure 2.5). Unlike the Möbius strip, the Klein bottle is a closed compact surface and has no boundary (Glendinning, 2012).

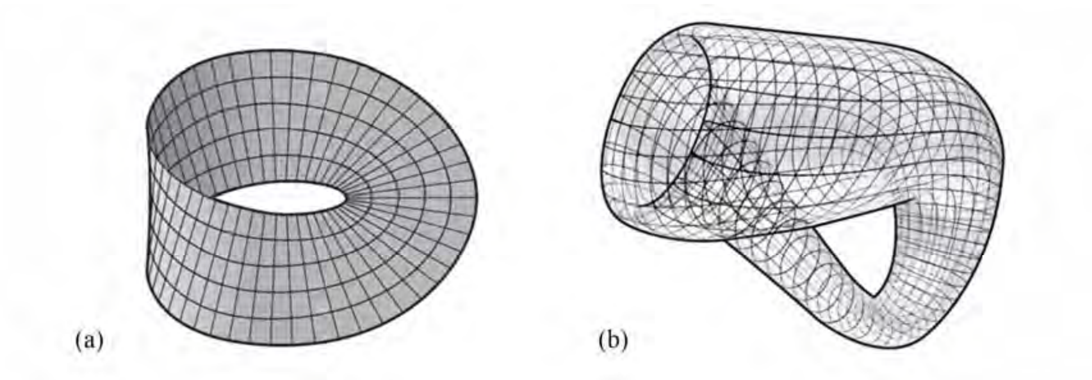


Figure 2.5: (a) The Möbius strip, (b) the Klein bottle (Glendinning, 2012).

Through utilizing the consequences of a few centuries of mathematical investigations on the nature of abstract spaces, the idea of a probability space can be made. The best-known case of which is Euclidean geometry, and non-metric spaces exemplified by an assortment of different geometries: projective, differential, topological. As DeLanda (2010) states, "A relatively simple way of distinguishing metric from non-metric spaces is by the way in which the component parts of a space, individual points, are identified. The metric solution is to give each point an "address" by locating the space relative to a set of fixed coordinates and determining the distance that each point has from those axes."(p.18) However, this recognizable system is not the main method for individuating focuses. Deciding the rate at which the bend of a space changes at a given point can be made and utilizing this quick rate of progress to distinguish it. The arrangement of organize addresses and turns into a field of rapidities and flow differs with slowness, the rate or gradualness at each point. An abstract space's structure can be portrayed by those properties that stay unaltered when space is changed, moved, pivoted, collapsed, extended. To understand in what sense two unique instruments can have a similar structure we require exceedingly invariant auxiliary properties since the metric subtle elements of their probability spaces will undoubtedly be extraordinary.

> A very important example of these invariant properties is the existence and distribution of special or remarkable points (or sets of such points) called singularities. This is the concept that we need to make the remarks in the previous paragraph less metaphorical: the possibilities with the highest probability of occurring are topological singularities acting as attractors (DeLanda, 2010, p.18).

Similarly, Derrida reestablishes the vital "dependence of absence and presence" as it identifies with material articulation. Derrida's model of the "space between" is profoundly valuable due to allowing a formless through its constitutive components. More critically, diagrams a strategy for looking at the unexpected architecture, the image, through its constitutive components, for this situation, programming code. As Tierney (2007) emphasized:

> Derrida's concept of spacing was used to justify the incompleteness of things. Within each constructed binary, A is the opposite of B; however, A needs B to exist—for example, figure needs a ground, outside needs inside, absence needs presence. Therefore, A always bears a trace of B, because they depend on each other for definition. Yet according to Derrida's concept of the supplement, A is also unlike itself because it always bears the trace of B. The combining of unlike things is what creates the space of différance or multiple readings, and as such it could be said to exhibit transmedia characteristics (p.76).

The variables spatialized field of relations happens as a major aspect of a bigger change in perspective, by complex systems and incorporating developments. A system's basic association is portrayed by vitality or data. The variables spatialized field of relations happens as a major aspect of a bigger change in perspective, by complex systems and incorporating developments.

In the digital realm, space is defined by where you are in the network and who you communicate within the network. Physically people can be close, be neighbours, but they can actually be much closer to somebody that they are connected to through dıgıtal means who lives on a different continent. Manuel Castells describes a space of flows which geography of network matters much more than the geography of traditional space (Stalder, 2006). That space has a poly-directionality network. Connections can be many to one, one to many, one to one or many to many. So that, there is a tension between space of flows and space of places. Taking Manuel Castells's work as a departure point, novel approaches such as smooth space, soft forms are under consideration of architects. As Juhani Pallasmaa (2014) states:

> Unconscious and unfocused creative scanning enables complex entities and processes to be grasped without consciously understanding any of the elements – much in the way that we grasp the entities of atmospheres. Even infants grasp the meanings of complex situations 'syncretically', without understanding separate details.(…)Architecture, too, calls for a deepened sense of materiality, gravity, and reality, not an air of entertainment or fantasy. Besides, architecture requires an integrating and emotively suggestive atmosphere.(…)But I think the notion of atmospheres is in balance with my understanding of the body image, or the embodied image, in its comprehensive, sudden grasping of the emotional and existential essence of a situation (p.26).

2.2 Flow as an Observable Phenomenon

The understanding of natural phenomena is a crucial addition to the debates regarding flow metaphor. Obviously, there are many phenomena that can be considered as *flow*. However, instead of representing all the flow effects in nature, in this section, some physical forms from phenomena perceived by senses resulting from forces such as gravity, electricity and magnetism will be discussed. Additionally, they all will be conceptualized around the notions such as the field theory, self-organization or emergence.

The creating of a model of a reality and discovering its laws means to abstract its nature and the flows in the atmosphere or in the ocean are described by the equations of hydrodynamics. The rendering of the complexity of reality in mathematical algorithms means to make all these phenomena graspable (Feicher, 2008). Theoretical considerations are combined with empirical experiences so that both data and observations enter into parameterization. The atmosphere, for example, has a variety of temporal scales. Climatic fluctuations or climate changes led by external mechanisms such as solar radiation, orbital parameter or human interventions transform clouds into their unique forms (Figure 2.6).

Figure 2.6: Cumulonimbus clouds and cloud formations on Earth (Url-2).

Turbulent motion is the natural state of most fluids. Turbulence, the random and chaotic state that fluids which hard to analyze, but the general idea is that energy starts out in these large scales and slowly works its way down to the smaller ones, where friction can transform that motion into heat. The pattern is like moving around a circle, like a clock's hand does, particles move radially from the centre outward through different length scales from large to small. In order to represent the patterns such as pouring milk into coffee or the ash plume from a volcano or a cloud, it is needed to visualize structures with the length scales (Figure 2.7). Large range of length scales is one of the characteristics of turbulence which are unpredictable and makes the calculating (or even simply modelling turbulence) with the great challenges (Davidson, 2004).

Figure 2.7: Coffee milk turbulence (Url-3)**,** Turbulence on Jupiter (Url-2).

Another atmospheric luminous phenomenon is Aurora, luminous phenomenon of Earth’s upper atmosphere that occurs primarily in high latitudes of both hemispheres (Figure 2.8). Free electrons and protons are thrown from the sun's atmosphere are blown towards the earth by the solar wind. In consequence of the weaker magnetic field at either pole, the charged particles are largely deflected to the poles by the earth's magnetic field so that the collisions occur at the poles and the interaction of the energetic particles with atoms of the upper atmosphere emit light (Url-3).

Figure 2.8: Islande côté Nord series, Vincent Guth (Url-4).

Some animals display biological compasses alike a sixth sense that makes them aware of Earth's magnetic field. A possible explanation for birds is the presence in the sensory system of an iron-oxide mineral called magnetite (Figure 2.9). Due to highly magnetic properties, the iron-oxides allow the birds to align with the magnetism of Earth. The other explanation is from quantum mechanics. some proteins which are sensitive to blue light create highly reactive atoms or molecules with a single valence electron. the blue-sensitive proteins remain active longer with the magnetism of Earth and this creates a colour shift in vision that the migrating birds can detect (Lavender, 2017).

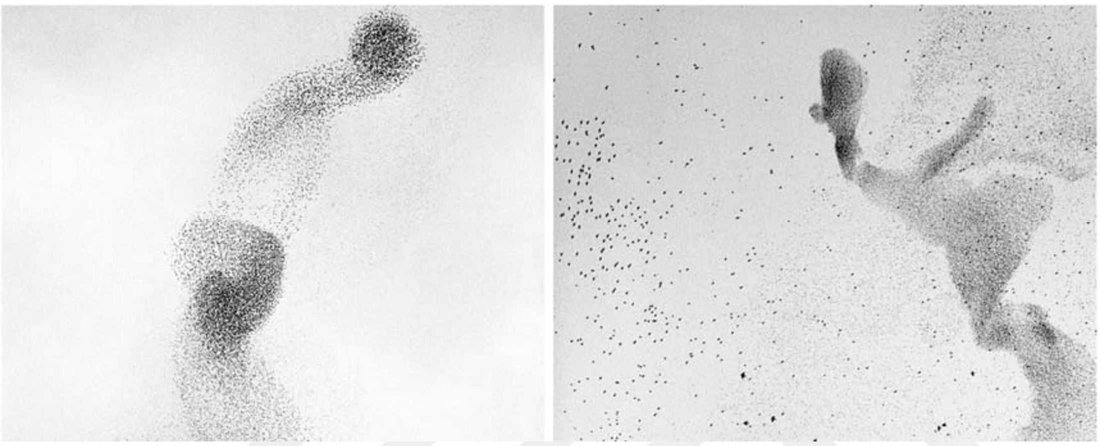


Figure 2.9: Murmur #8 and #20, Richard Barnes (Url-5).

As a field phenomenon, the flocks are defined by local conditions taking into account the fact that obstructions do not have an effect on the whole. Just like fluid adjustments, flocks get roughly similar configurations owing to localized behaviour patterns. The flocking behaviour displays the same structure even if it is large or small, so cumulatively similar configurations emerge (Allen, 1999). The motion resembles swirling clouds moving in the wind (Figure 2.10).

Figure 2.10: Sheep muster, Tim Whittaker (Url-6).

In T*he Hunchback of Notre Dame*, Hugo (1884) makes a comparison between the coursing crowds through the city and a body of water. He writes:

> The palace yard crowded with people looked like a sea, into which five or six streets, like the mouths of so many rivers, disgorged their living streams. The waves of this sea, increasingly swelled by new arrivals, broke against the corners of the houses (p.2).

In a similar manner, Elias Canetti considers crowds as forms of nature as like fire, water, or flows of sand (Figure 2.11). Stan Allen (2000) states Canetti's approach "proposes a broader taxonomy" to the notion of flows with the reevaluations, not only with crowd features but also with extending the notion to "the flowing of rivers, the of crops and density of forest". According to Canetti, "The crowd always wants to grow; within a crowd there is equality; the crowd loves density; the crowd needs a direction" (p.56). This approach is like a complex space where the sea, winds and colours are mixed together. Geographies testify to movements. Desert can remain as desert or sea can remain as sea, but there are changing spaces in the unlimited diversity, in which there is no clear what is going to happen.

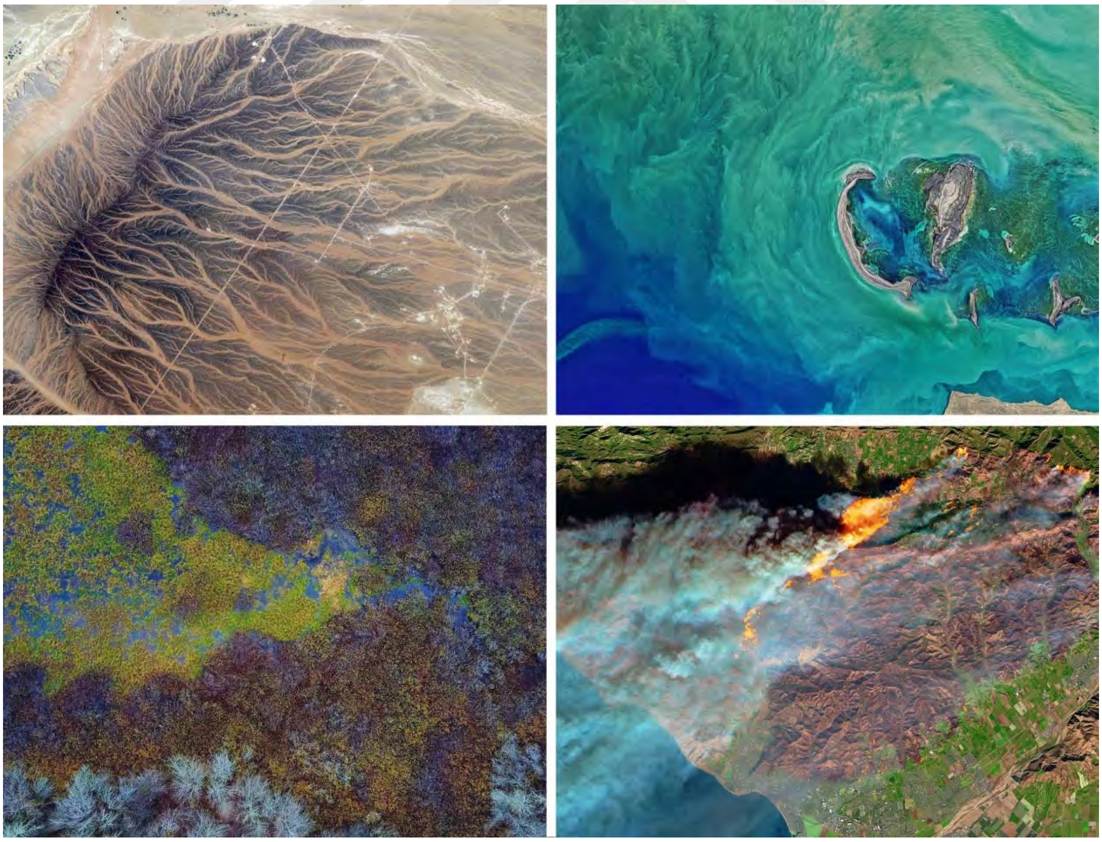


Figure 2.11: Satellite images (Url-2).

2.3 Flow as Changes of Energy and Equilibrium

Differential equations describe the motion of the fluids. In principle, the equation defines the initial movements of each element in the fluid and the form of the boundaries of the fluid. In many simple conditions, the fluid flow is mainly smooth and the boundaries of the fluid have a regular pattern, such as a slowly flowing river with no rocks or obstructions. However, an irregular place which has some obstacles. The elements of the flowing water get affected by each other and the external influences, so that the motion of flow changes. It may turn into bubbles, foam and spray; hence the flow of the fluid becomes unpredictable, random and chaotic. Yet, even a typical randomness is an order in an overall context which is set by the boundaries and the motion behaviour of the water (Bohm, 1987). In this connection, as far as the Brownian movement is concerned, small particles such as pollen grains move on a random path in water or gas which have smaller particles (Figure 2.12). That random movement of the particle is the result of being under many external forces coming from random directions with incidental intensities (Url-8). In systems of many particles, each particle has the case of possibilities of infinitely complex variations.

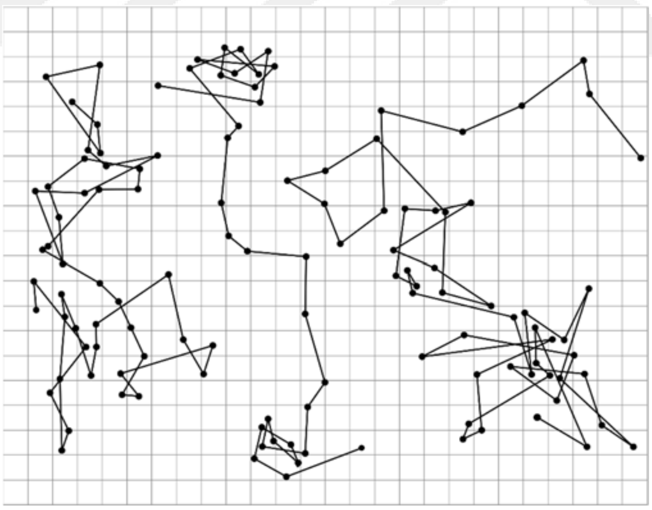


Figure 2.12: Brownian movement of a colloidal particle of Jean Perrin (Url-6).

In the reinterpretation of the concepts of space, permanence, time and causation, the theory of relativity and quantum mechanics have played a crucial role. Nevertheless, in this entire process of radically transforming our conception of the world, the significant role is based on thermodynamics, which alternated the view of the world by the means of improvements like the thermodynamics of open systems. The major thing about thermodynamics is its second principle which leads a creative approach.

As an energy form, heat that is given to any system is equal to the sum of the heat left in the system and the remaining heat in the system. In thermodynamic systems in general, the heat given to the system is transformed into another specific 'energy' within the system. Regardless of the form in which the energy is transmitted, the energy entering the system in a closed system must equal the energy generated (Fernández-Galiano, 2000).

2.3.1 Entropy and complexity

Entropy, the second law of thermodynamics, simply means irregularity in a system. It is the measure of disorder in terms of the amount of heat and work that is associated with a system. There are both chemical and physical examples of entropy such as wood on fire or melting ice. after setting on fire, the wood becomes ash, gases and smoke or the solid state of ice transforms to more disordered states (Figure 2.13). There is entropy everywhere where the energy and mass are, and irregularities in the universe tend to increase continuously. The entropy of an isolated system can never diminish and always tends to maximize its entropy. As long as the system is not energized from the outside, it means that the order will become irregular and the irregularities will turn into chaos (Fernández-Galiano, 2000). In this regard, a river's chaotic movement is an interesting example. A whirlpool, even though it is changing, irregular and fluctuating in a complex way, remains in a certain region of the river. It may be effected of neighbouring rocks or the riverbed. It may have new variations in space due to the velocity of the river. In measure, the overall range of variation of the whirlpool comprise both inward and the outward changes (Bohm, 1987, p.134).

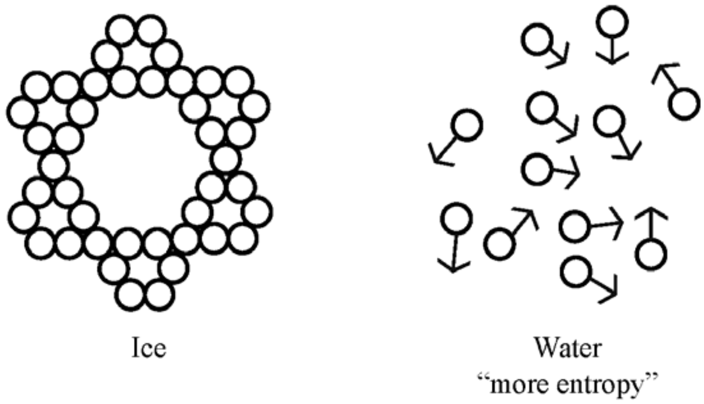


Figure 2.13: The entropy increase depending upon the state of matter.

Particles start to bouncing around with more momentum and velocity if the average kinetic energy goes up in a system. The entropy of a system is not dictated purely by the position of the particles. The higher temperature leads the system to have a larger number of potential velocities as well as more different configurations in three-dimensional space. This irregularity also depends on the area within the size (Figure 2.14). If we consider an isolated system of interacting particles and left it to itself, each particle acts in a way that the overall motion tends to be chaotic until the thermal equilibrium of the system which has no flow of heat or energy within it. Yet, in the equilibrium state, the system reaches to the maximum entropy. This is like a state that the transformation of randomness turns into order. From this point of view, "The question of randomness is an aspect of the general context dependence of order." (Bohm, 1987, p.135) As opposed to timeless and orderly mechanism, entropy presents degradation, disorder, irreversible time and change.

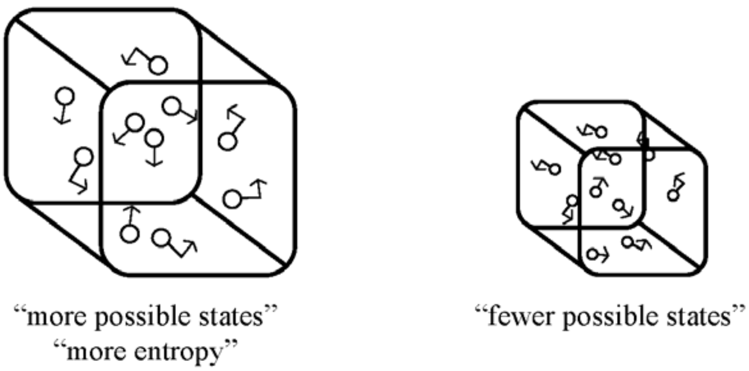


Figure 2.14: The entropy increase depending upon the system volume.

The conception of time is also altered by entropy that directs time while marking the rhythm such as becoming or changing. Thermodynamics is called as "physics of becoming", in contrast, "the physics of being, classical and quantum mechanics." (Bohm, 1987, p.133). The science of events acts as the arrows of time. Entropy is not only related to the degradation of energy, the degradation of order in general terms should be taken into account. Mechanical time of natural processes does not also flow uniformly. Blooming times of flowers or growth of the branches of a tree are on different days their positions, variations of temperature or wind. Paraphrasing Bergson's approach, time is the creation of forms. To determine the time in processes, the decrease of entropy marks the creative occurrences, unlike the marks of the swinging of the pendulum or the increases of entropy which degrades the form. the decreases are like slight stops of systems (Fernández-Galiano, 2000, pp.54-60).

2.4 Architecture of Flows

In the architectural field, the design is considered as the organization of materials that control and arranges energy flows. As a whole, it is an energetic organization that balances and sustains material forms, concurrently and indivisibly. Though matter and energy are divided for identification, they are indistinguishable connected (Fernández-Galiano, 2000). In the modern era, architects use the concept of flow through circulation and movement in the designs of buildings as well as urban designs. The new approach to flows has evolved to designing to the flow by the means of shaping the flow's itself. Animation softwares allowed to simulate the mutation of the virtual transformation of the designs in time. Although animations have an experimental and virtual "nature", a new understanding occurred towards the notion of flow. In recent years, architects focused on imagining cooperation of the unmanageable forms of flows and material stability of architecture.

The conventional definition of the architectural image dismissed any relatedness amongst time and space; in other words, the architectural image was always static and settled. In fact, all structures and forms that exist uncover themselves in space in time. The most recent digital techniques, as in animation which the duration and sequencing can be controlled, deliver out relativeness of time in the virtual forming of architecture. Manuel DeLanda (2002) reviews forms as a notion inherently existent with change. He asserts:

> Form is no longer something static imposed on the outside on structure with homogeneous properties or a behaviour that can be assimilated by the characteristics of solid modelling, but is rather influenced by the properties of the tools used, under the form of the singularity of the digital material. Therefore, it brings out the generative processes and their possibilities connected to the concepts of interactivity, modifiability and evolution among the principals (p.130).

Architectural image now exhibits differentiation so that it is uncertain and conditional. It actualizes itself via unpredictable movement of becoming other. This can make a significant differentiation in architecture or, likewise, in any other creative process through altering assumptions or ordered structures.The virtuality of digital media constructs movement and illusion. Hence visual evaluations cannot be on a fixed or static description.

> Flow" in English coincides with two words in French: "flot" and "flux". The French "flux" translates precisely into the English "flow". The word flot (pronounced quite similarly to the word flow) carries a slightly different meaning, referring to a stream or a natural movement of matter, such as a watercourse. An ambiguity arises here from the fact that the words "flow", "flux" and "flot" have an intimate, yet asymmetrical relation. Hence, a "flux" is not the same thing in French and in English (Delalex, 2006, p.34).

The debates of flows in the field of architecture mainly are over whether the shape that should give "flows". The initial question is how architects turn the flows into the design. Surely, some distinctive approaches to flows have been developed in time. Some architects focused only on soft topographies or sculptural building forms. Some moved beyond questions of forms and extended the debate and started to question field-like organizations such as the energies of flow, information and people on-side.

Antoine Picon (2015) sees Deleuze's folding notion as a turning point in the architectural design field. Folding as a metaphor, in literal means, introduces a envisage complexity. There is a similar approach in Lynn's manifesto *Folding in Architecture* which suggests "smooth transformation involving the intensive integration of differences within a continuous yet heterogeneous system" (Carpo, 2013, P.30). Lynn focuses on computer visualisations as a design tool that relates the notion of flows to the techniques. In the designs, three-dimensional and animated spaces turn into a virtual space of flows itself (Figure 2.15). In order to shape forms, Lynn works in a virtual animated space of moving forces (Figure 2.16). Forces lead to form manipulations and the repetition of forms creates an undefinable identity within a field of gradient influences. The simulation and manipulation of moving forces creating "fields effects" and the gradients of influence are the major focuses of his architecture. that architecture is the presentation of the variant forces that act on fluidity, mutation, evolution which opens the horizon. Gradients of the formations with splines and curvilinear lines allow the surface deformations which are like shaping forces. Flexible surfaces having changeable parameters define evolution in time.

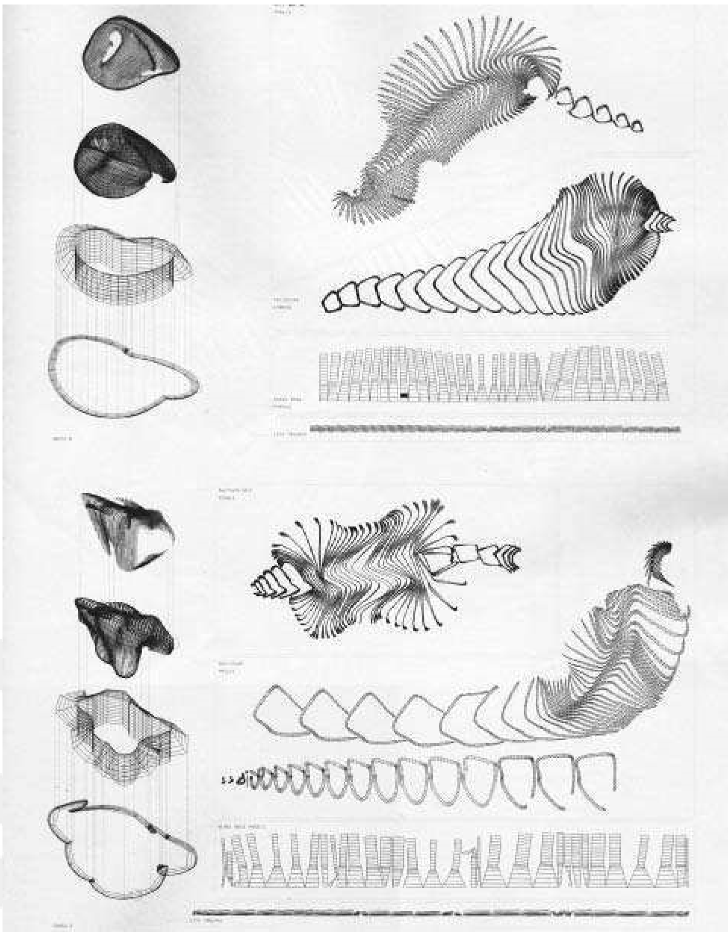


Figure 2.15: Embryological House drawings, Greg Lynn (Url-7).

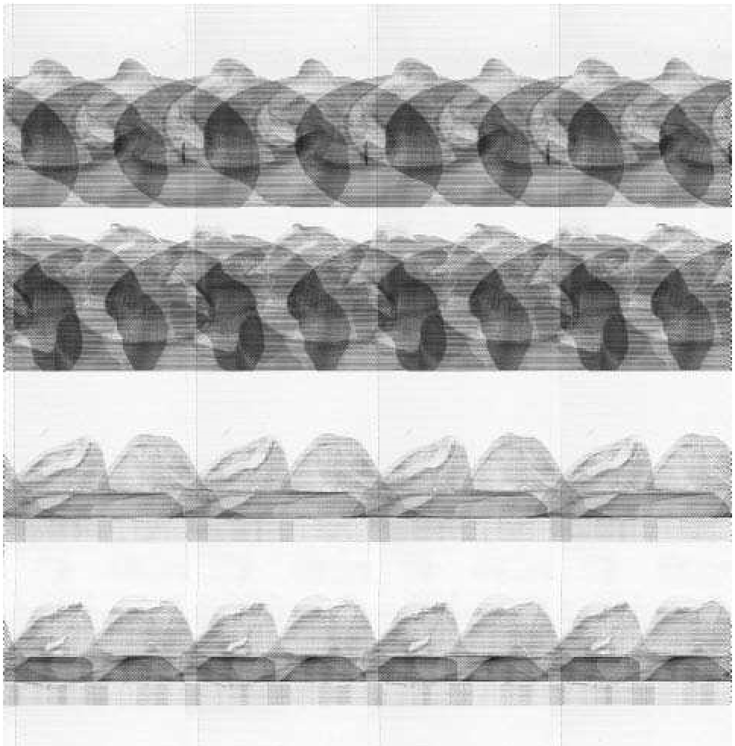


Figure 2.16: Still from the animation of Embryological House, Greg Lynn (Url-7).

Considering digital architectural form as a trace of a frozen moment of a flow can be conceived as a projection.Form in a flow, as an element or a moment, is still a frame produced by freezing the moving geometry. As in Lynn's works, animation provides to capture the transformation of controlled models over time so that diverse variables recreate different solutions simultaneously. The virtual space reflects a very fluid space via visualising flows, turbulence and movement and that shows a real transformation of space (Flanagan & Booth, 2011).

In Stan Allen's theoretical research on field dynamics, as opposed to hierarchical compositions. Allen proposes to treat architecture as a network that assists in organising and distributing the changes in urban space. The flat and fluid organisations do not have any particular shape or any dominant pieces (Figure 2.17). As like urban spaces, some parts are dense others are barely distinguishable. The systems of flows, movements and exchanges are organised and managed in network structures. His approach is not over of a creation of flows, but rather encouraging them. Physical exchanges between people or objects are operated by these "arrangements" of view. Allen interprets the forces as foundations to shape a genuine city. As he (1999) states:

> Any formal or spatial matrix capable of unifying diverse elements while respecting the identity of each. Field configurations are loosely bound aggregates characterized by porosity and local interconnectivity. Overall shape and extent are highly fluid and less important than the internal relationships of parts, which determine the behaviour of the field. Field conditions are bottom-up phenomena, defined not by overarching geometrical schemas but by intricate local connections (p.92).

Field conditions are fluid organisations which have no particular scale and redefines the urban contexts in the continuous field of interactive forces. The flexible geometry of flow-fields relates to the physical (such as crowds) expression of movement and the transition between the physical spaces and the abstract flows. Diffuse form approach integrates boundaries, people and objects. It is like a relation network which is poly-directionality as Manuel Castell suggests. However, it alludes to more mathematical, dynamic and simulatable changes toward a consideration of systems and networks. It challenges and expands the edges of architectural practice by rethinking both architectural object and city through re-envisioning of diagrammatic practices used to transcode information and can enable a crucial evolution of design disciplines.

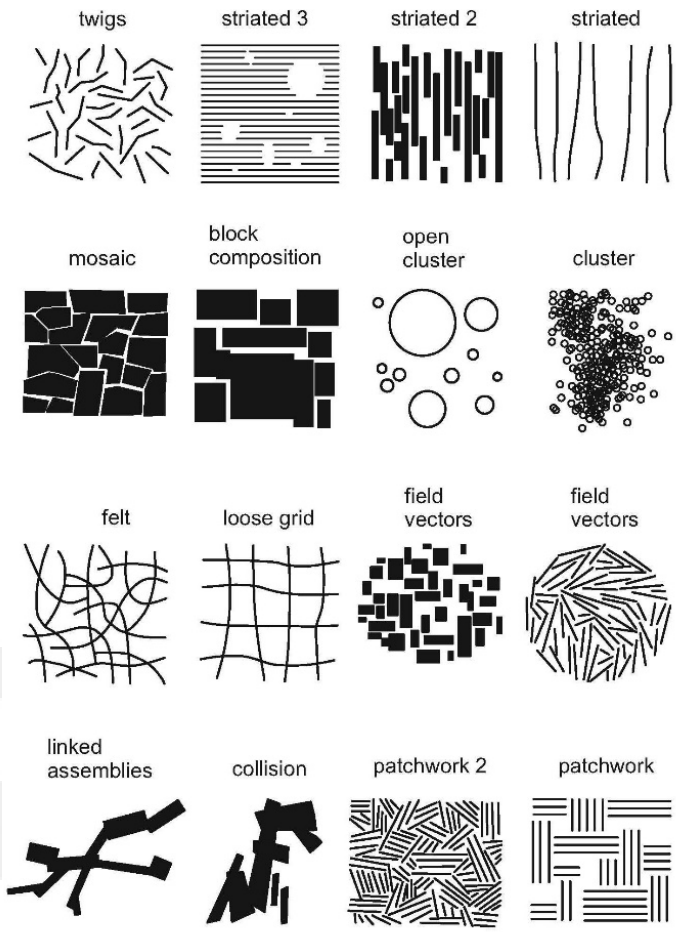


Figure 2.17: Diagrams of field conditions (Allen, 2000).

Amplification strategy of Sean Lally is on the changing the existing properties of spaces until making the expected condition. By strengthening the energies, producing an architecture is designed the parameters associated with climates such as “pressure, temperature, humidity, solar radiation, and precipitation” (Lally, 2014, p.36). Manipulating these parameters creates novel spaces which cannot be made with merely the building materials. This approach alternates the architectural aesthetics and the definitions of shapes or boundary. Shaping energies by calculating and controlling the energies them needs simulation of fluid dynamics and the gradient boundaries of energy differences. The shape of architecture is a dialogue between the material energies which create gradient boundaries and the body’s sensorial envelope which detect the gradient boundaries. As Lally emphasizes (2014):

> Particles and waves of energy produce gradients of intensity, requiring the human body’s sensory perception to be sensitive enough to detect and respond to the properties of those more blurred edge conditions. The shape of this architecture is a result of a precise calibration

between the senses of the human body and the material energies that the body can perceive and come into contact with (p.38).

Setting up hot pockets in open space and producing thermal zones generates new artificial landforms of social aggregation (Figure 2.18).

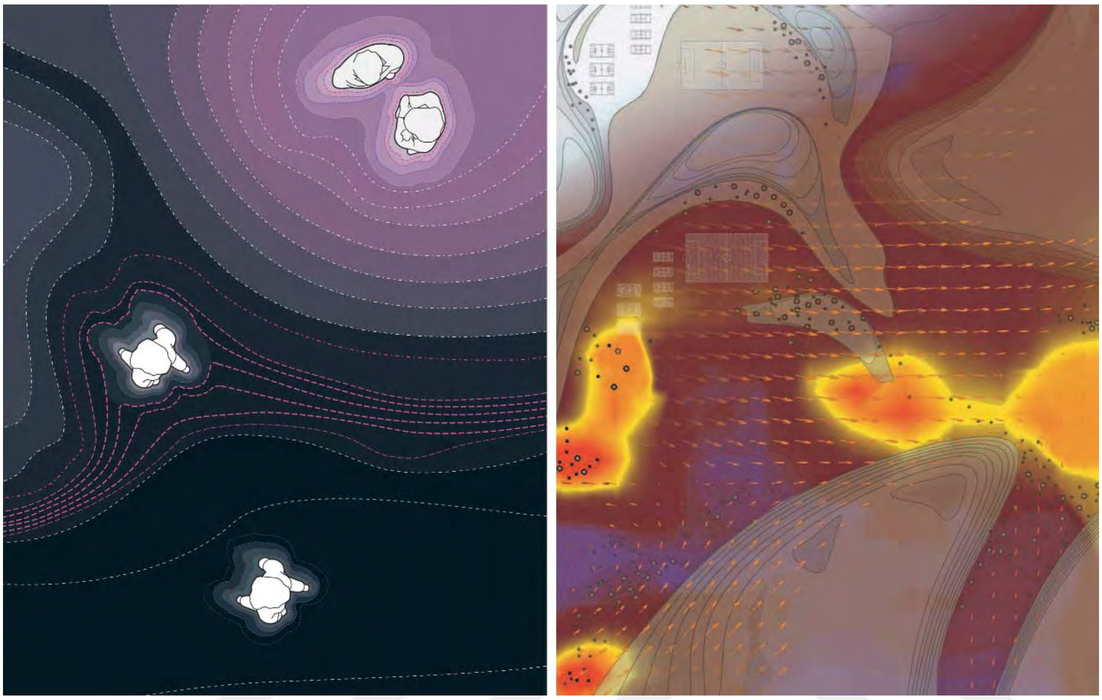


Figure 2.18: Diagram of shaping energies and simulation of Vatnsmyri urban planning (Lally, 2014, p.128).

Beside the simulations that define spaces with gradients, particles, temporal shapes, Toyo Ito's designs abstractly have the same approach. A sketch of Ito which composed of people under cherry blossom trees and other elements such as the petals and fabric screens shows the fundamental principle behind his architecture (Figure 2.18). All the elements in the sketch create a space and give an opportunity people choose their exact place through the wind, the views, the ground situation (dry or wet) or the tree that they wanted to be under. That space creation is alike the dissipation of the ripples in the void (Figure 2.19). Same as that dissipations, Ito focuses on an architecture dissipate infinitely. In Ito's view, architecture should take components of natural environment such as light, water or wind into account and also seek for transparency and homogeneity. Even his design diagrams are like evoked imagery from the natural world. Ito's flow approach is metaphorical. Mainly “cubic envelope buildings” do not seem to be affected by the flow notion in the shape (Figure 2.20). Though, the designs make a clear distinction between solid and stable, moving and fluid. These envelopes are not facades, they are sectional cuts it is actually meant to continue infinitely in space. The circulations in the buildings arrange the physical flows of people like flows of air or water with thermodynamic models after abstract desicions.

Figure 2.19: The sketch of people under cherry blossom trees and dissipation of the ripples, Toyo Ito (Url-8).

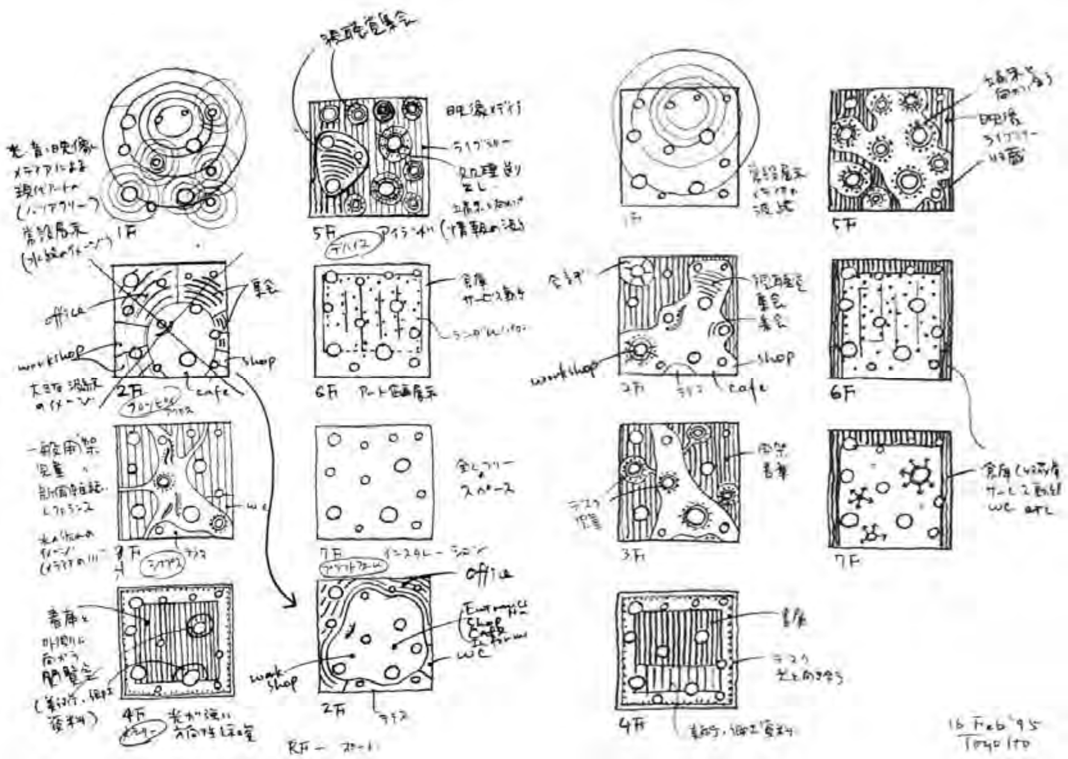


Figure 2.20: Concept diagrams of Sendai Mediatheque, Toyo Ito (Url-9).

2.4.1 Permeable boundaries

Toyo Ito (1999) approaches the phenomenon of boundary in relation with the metaphor of "floating". According to Ito, human inhabits in nature and society through the experiencing bodies and the perception of 'inside' and 'outside' over the body can be considered as the floating of water. 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. 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.

The energy change, the flow of the energy and the concept of entropy have been approached by various scholars. Beesley (2014) emphasizes that current developments in technology may allow creating a completely new built environment typology using thermal, acoustic, chemical and electromagnetic energy. In the context of boundary concept in architecture, Beesley criticizes the conventional assumption of the boundary which is reduced into the basic shapes of "circle or sphere" (Figure 2.21). He argues that the conventional assumption of boundary affects 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 (Budak et al., 2017)

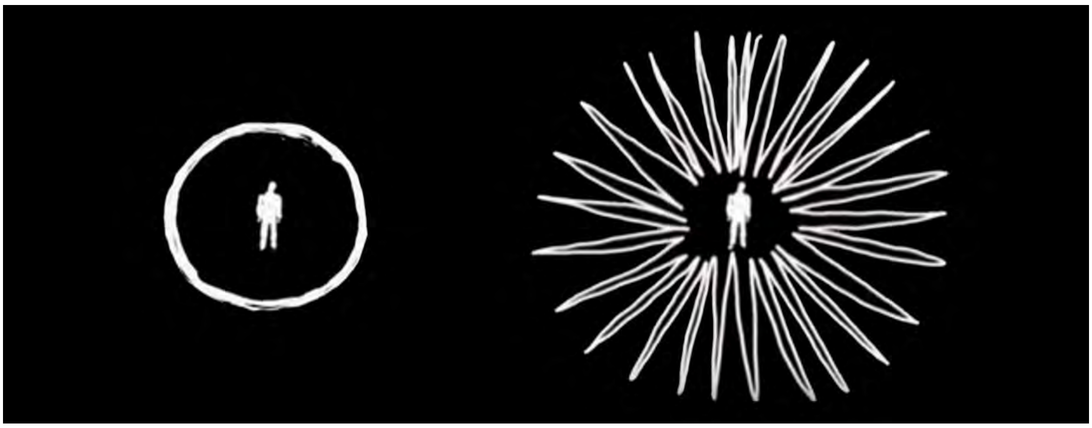


Figure 2.21: Representations of ideal boundary and permeable boundary, Philip Beesley (Url-10).

Based on the same form language, *Hylozoic Ground* (Figure 2.22) acts as a living creature which response to the user with air, water and light. The installation consists of microprocessors and proximity sensors, which are attached to thousands of lightly structured and digitally manufactured parts, reacting to human beings. This responsive environment acts as a gigantic lung that exhales externally and is an example of a permeable boundary representation in the sense that it does not define a sharp boundary. Beesley (2014) questions how energy changes can be incorporated into the architecture. The projects on the possibility of using air, gas or liquids as new architectural material by manipulation work as a "living mechanism" with his own expression, perceiving the sensors personally and reacting with motion, heat or light. Current developments in technology may allow creating a completely new built environment typology using thermal, acoustic, chemical and electromagnetic energy.

Figure 2.22: Hylozoic Ground, Philip Beesley (Url-11).

In *Earth Moves: The Furnishing of Territories*, Bernard Cache (1995) 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" (p.81). The view of our surroundings can be considered as a reflection of our interpretation of them. Therefore, the way of seeing is crucial to the understanding of space, architecture, territories and everything else. Therefore, 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. He draws an inflection in between points (Figure 2.23).

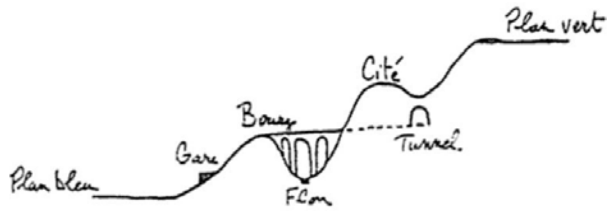


Figure 2.23: Louve city definition of Bernard Cache (p.6).

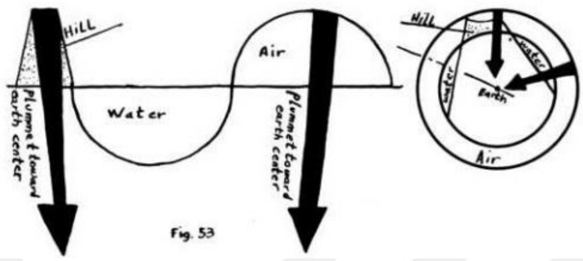


Figure 2.24: Earth, water and air drawing by Paul Klee (p.24).

Reading our surroundings without identity allows infinite change and creative possibilities that might push potential developments (Cache, 1995). Accordingly, re-reading the concept of the boundary between the self and space through different modes of abstraction is essential to gain a new understanding. Similar to Cache, in *Pedagogical Sketchbook*, Paul Klee describes the world, nature, naturalness, everything on earth, water, air, dimensions of the human body with moving lines (Figure 2.24) through a free creation of abstracted forms (Klee, 1925). In a similar approach, John Ruskin's illustration that shows the common forms with the curvature of mountains, trees, plants, and shells, defines abstract lines which derived from nature (Figure 2.25). In his view, various curves at very different scales are to demonstrate infinity. this interpretation towards the dynamic behaviour of natural elements exhibits his attention to variations and flows.

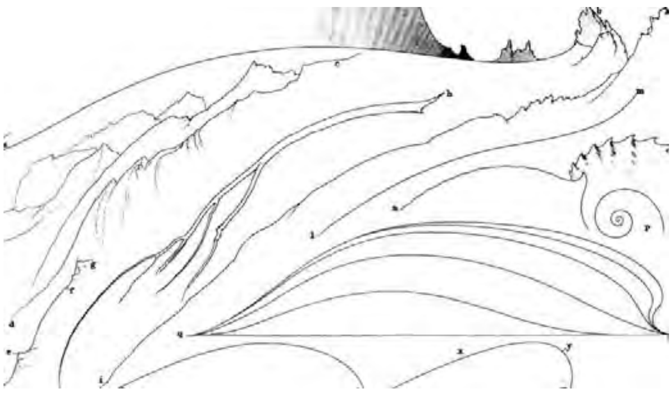


Figure 2.25: Abstract lines, plate from The Stones of Venice, John Ruskin (Url-12).

3. CREATIVITY AND SUBJECTIVITY

Computers have languages and in order to learn how to communicate with a computer, firstly the user need to learn that language. Besides that, design which is art with a content in a way, has an ambiguous “nature” with many unpredefined processes. The intersection of technology and design, how they overlap or how they can make a synthesis are quite experimental processes and that process also might lead the designer to a great discovery. In this section, digital creative processes and some computable aspects of the notion of flow will be introduced.

3.1 Digital Creative Process

> In my first paragraph, I say “You are alive”, though I was not specific as to who “you” really is. I imagine that text might someday simply reside on a public-data server. The giant information organisms we call “webcrawlers” quietly creep over the web, assimilating new information into their behemoth brains. A brain cell might one day go active and attempt to interpret my text and get the line that declares “you are alive.” And, thus, I christen thee to be alive, my friend computer (Maeda, 2004, p.50).

Computers as a medium in the world of design have changed both the final products and the creative process. Unlike conventional methods, computation lets new possibilities, unique designs which can be never imagined or be drawn without computation. Obviously, the challenge is to uncover the properties of computation. Since, while creating a line, drawing with a mouse or a pen does not make any difference (Maeda, 2001). Computation of generative images needs a completely described set of commends to appear in the display. Therefore, instead of focussing on how to visualize the idea, abstraction of the idea comes into prominence.There are numerous sorts of code. Some of them represents a series of instructions and mainly is called as an algorithm that characterizes a particular procedure with enough detail to enable the directions to be taken after. There are also numerous approaches to compose an algorithm. The structure of algorithms is like many different ways to choose to go from one place to another. Each person can reach their destined place via various directions (Figure 3.1).

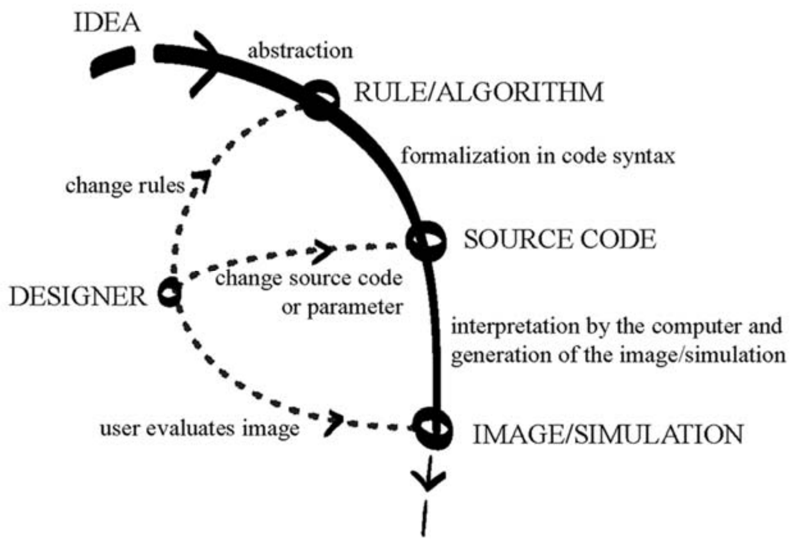


Figure 3.1: The reinterpretation of program flow diagram of Bohnacker.

The design process has undergone major changes with programming and therefore computational design. Design ideas must be abstracted and translated into the syntax of the computer's language so that they can be “told” to the computers. The generated source code is read by the computer and so that the outcome is produced. In this process, the designer constructs the algorithm of the idea and the source code, evaluates the resulting product and changes the code and algorithm if deemed necessary. Thus, the design process itself is emergent when the outcome is not defined determinately.

> Writing code is one gateway for realizing these new forms. Learning to program and to engage the computer more directly with code opens the possibility of not only creating tools, but also systems, environments, and entirely new modes of expression. It is here that the computer ceases to be a tool and instead becomes a medium. We hope the following chapters will provide evidence for you to draw your own conclusions about the potential of software in the visual arts (Reas, 2010, p.25).

Every a programming language encourages a certain mode of thinking. Writing a program with a visual programming language provides an alternative way of thinking with code. The use of software in the arts can be made for production or conception. Production can be identified as computerization which the computer is used to produce a preconceived form; on the other hand, conception is basically a computation. Conceptualization requires the computer that participates in the development of the form. As Bernard Cache (1995) defined “CAD systems have certainly increased the productivity of the idea, but fundamentally they offer no advances over the work done by hand. Now, we can envisage second-generation systems in which objects are no longer designed but calculated" (p.87). Even though software proposes many creative tools, they keep the designers in the limitations of existing. They even separate in between by the production of specific types of forms. In order to go beyond the limitations, "It is necessary to customize existing applications through programming or to write your own software" (Reas, 2010, p.25).

On the computation and computerization, Fishwick (2006) mentions two main tendencies in human-computer interaction. Before Human-computer interaction, the users were assumed to conform to the machine. However, in the first generation, "The aim was to minimize the cognitive load on the user by optimizing the interface to best fit the abilities of the general human" (p.358). In the second generation, the aim turned into "supporting the continuing dialectical development of the human use of computer-based tools "(p.358). Human-computer interaction comes into prominence and computers became a tool in the skilled workers' hands (Figure 3.2).

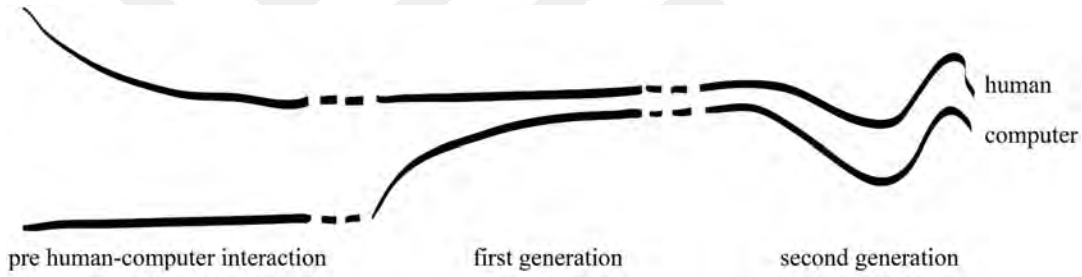


Figure 3.2: The reinterpretation of the tendencies classification of Fishwick.

In early times, reducing the amount of time that needed to create a complex, repetitive composition was often the motivation for the early adoption of software and its integration into the creative process. Comparing working by hand, now the artist can create many versions of their work and choose the best in the same amount of time (Figure 3.3).

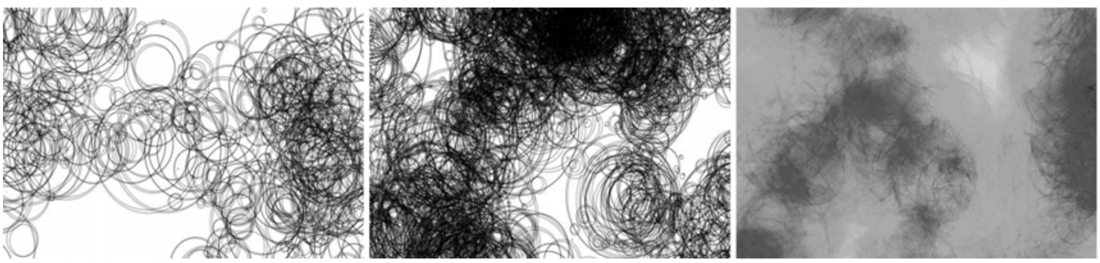


Figure 3.3: Generative design, Matt Pearson (2010, p.114).

3.2 Computation of the Notion of Flow

This section presents issues in the notion of flow as a way to establish the dialogue between creativity and computation in the process of conceiving digital representations. The creative process is discussed in terms of representing conceptual and perceptual structures of flow metaphor across computational and visual expressions. In this context, correspondence between conceptual and actual structures in computing are investigated. It is also presented preliminaries and essentials in the computation for defining flow metaphor in visualization.

3.2.1 Animated form

"Increase in movement produces more fluid relations, e.g. in water or in air, the ideal dynamic media" (Klee, 1956, p.255).

An element or a moment in a flow can be considered as a still frame produced by the freezing movement of geometry. The forms are also commensurable to something that happens, an occurrence or an event. another way is its production through in a computing engine to create it direct deformation or parametric variation (Picon, 2010).

Contemporary digital designers generate their projects in complete reality with its continuous fields and forces that generate motion. In this approach, form does not appear as determined from outside, like a figure cast in a mould. It is rather be shaped by forces to constitute the true context of the project. The reason for experimentation in computational outline is to investigate the structure and properties, the way they and their formal items can be controlled. As Tierney emphasized (2007):

> An operational approach to architecture allows designers to subjectively observe unfolding over time, such as the growth of a plant, or the different patterns and relations that occur through inhabitation of a space. Form is then generated dynamically through the interaction of the designer, as well as the working of the algorithm (p.121).

Animation methods deconstruct the terminology of form-generation, to examine the metaphors in use as a means to acquire a deeper understanding of the process. Form-generation, here, is mainly related to time, growth, and movement. In actuality, all objects change over time; it simply depends on the frame or breadth of measurement one uses (Figure 3.4). In other words:

> Every object is actually an event. For example, if one were to monitor a chair (a supposedly static object) in a classroom over the course of a 24-hour day, it would seem to be animated, that is to say to have a life of its own, constantly moving and migrating as a result of the actions of its numerous occupants during the day (Tierney, 2007, p.121).

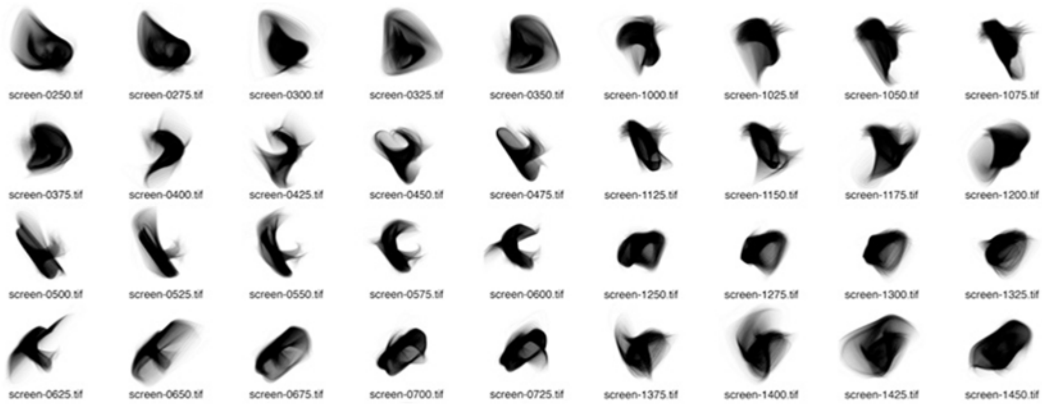


Figure 3.4: Contact sheets for Twill, Matt Pearson (2010, p.18).

Through a programming language, the computerized image is built, not drawn. Obviously, the digital image is constantly relative, continually opposing any essentializing endeavours. This can lead to creative processes if learned by other mediums. Provided that, at that point, aesthetic discipline is needed to be available to redefinition by the reception of computerized strategies.

To describe motion in still images, either a series of images of change are drawn, or moments that affect motion are captured. Symmetry or order is thought to be static, while asymmetry and confusion are said to express variability and movement (Gombrich,1982). The lack of geometric clarity may increase the impression of movement. During looking at a picture, the moments when the eye sends the “difficult to capture” message to the brain may be seen as images depicting movement. Gerard Richard's paintings can be a powerful example of this situation (Figure 3.5). The difficulty of combining the parts of the observer may seem like the difficulty experiencing when finding out the body and limbs of a person dancing in real life. Richard obfuscates and enhances the imagery. It gives the impression that his paintings are moving for a few seconds. Even the repainting of photos of the dead bodies, the viewer questions whether the place where the body is on the ground or floating in the air.If the visible world and the perception of the images were not a process in time, static images would not create perceptions about motion.

Figure 3.5: Singer and Man shot down, paintings, Gerard Richard (Url-13).

In order to describe dynamic processes or movements, visual series of flow-lines may be used, therefore any rule, being a dynamical rule, prescribes a flow. A dynamical equation has a continuum in the visual output if the flow-lines can be transferred onto each other. If the reference is given from the time period when the computer is not being used, Paul Klee's sketch series on form represents the movement of nature in an abstract way (Figure 3.6). From the simple forms to the complex combinations of pictorial elements, movement remarkably stands in his drawings. The hand-drawn images are gestural, therefore it is contingent on the artist's momental movements. Digitally constructed process-image operates as a set of instructions due to underwritten in code and can give unexpected results in the run.

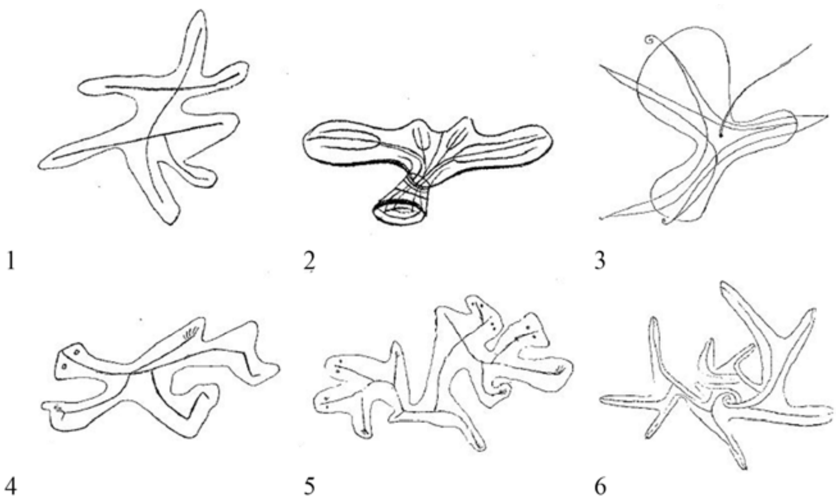


Figure 3.6: Dynamised starfish, pencil drawing (Klee, 1956, p.61).

The moire pattern's transformation also resembles an animated continuum of flow (Figure 3.7). Even though the moire effect is an analogue method, shifts between layers gives wavy results. The moire effect is created by overlaying two or more relatively simple patterns. the alignment overlap and differences between the component fields cause secondary patters to appear. The emergent organisations of wavy areas, curved lines and the complex patterning of the moire effect is the interface that occurs between two relatively simple and repetitive fields of units. If one shifts the component fields, the pattern shimmer, disappear and different ones appear (Hesel & Menges, 2006).

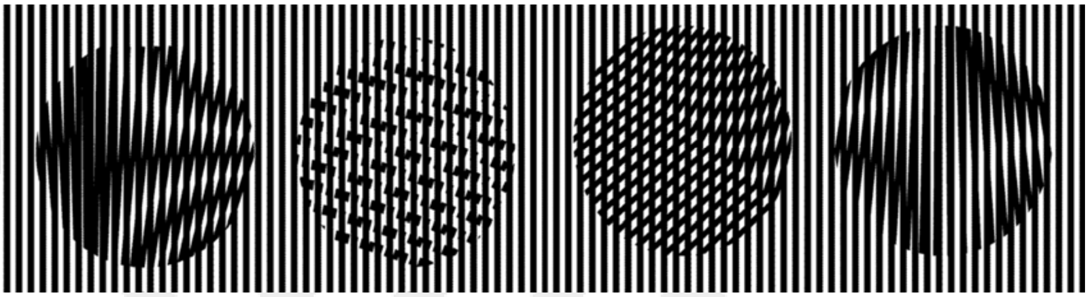


Figure 3.7: Moire pattern (Url-8).

3.2.2 Data series visualization

Data can be a medium for digital realism and its variation in the process makes visualizations fluid. A time-series visualization shows data collected over a long period within a single image. It compresses many moments into a single frame. A time-series image can be a single, static image or it can be an animated image that combines data through motion. By using time as the ordering principle, changes become clearer (Reas, 2010). Collected data can describe and represent the things that aren't visible. This makes data visualization is interesting because the same exact data can give different perspectives. For example, in their project *Cabspotting*, Stamen Design highlights patterns driven by data which is the New York taxis' paths in this case (Figure 3.8). Traffic data on taxis in a city tell us about citizens' daily routes in a city through the rhythms of data transition. In the project, through line density by tracking the devices attached to the taxis the city grid and circulation patterns are drawn. Global positioning system data points are connected by lines visualising the paths. In visualizing data, even though inputs are totally given, biases can never be totally avoided.

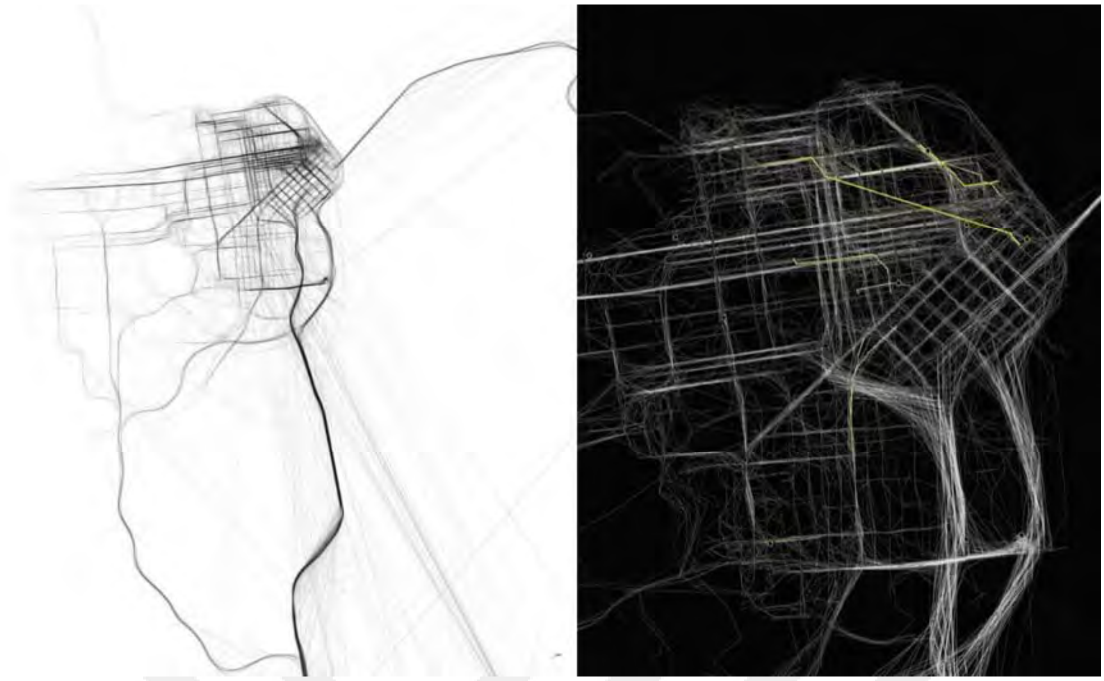


Figure 3.8: Cabspotting, Stamen Design (Url-14).

3.2.3 Simulating the complexity

Simulations consist of three parts such as variables, a system and a state. A variable, which is a value, represents a component of the simulation. A system is the way of interact variables interact. The values of the variables are the state of the system. To simulate anything there need to have an infinite number of variables. Making a software for simulation means selecting a finite number of variables from an infinite number of options and all simulations run as a series of time steps. After the simulation starts, each time at each step the values are recalculated. Simulation is the creation of the possibility of form and very open-ended.

The use of simulations can be the reproducing the natural world or generating novel and unexpected forms. If the system that wanted to be understood is too large or too complex or it is needed too much time, it is quite hard to explore a system. Computers (or computing) offers a new way to explore and to test. Many natural phenomena now can be described in equations and procedures, therefore flow simulation has been explored in depth using computers.

To observe the movement of particles, the water ink diffusion experiment would be an easy to explore example (Figure 3.9). Particles behave in two ways. The ones in the high-density ink areas fall to the bottom of the water, however, the ones in the low-density areas move alike to floating in the water. Due to the surface tension of the particles, the water and the ink are fixed to each other. This is an observation that simply describes the movement of liquids in slow motion as a result of surface stresses and density differences.

Figure 3.9: Motion of the ink in the water, personal experiment.

At slow flow rates, the straight and parallel streamlines to the direction of flow can be depicted simply in terms of two-dimensional streamlines. Fluid flows develop chaos when a certain threshold is exceeded. A velocity field is unpredictable and fluctuates randomly produce a large change to the motion of fluids. When the mean flow becomes into an unstable and more complicated laminar motion, a sequence of such instabilities turn to even more complex and random structures. These presences of multiple swirling motions, called turbulent flow, can be observed when watching ocean waves, rivers and streams (Figure 3.10). When there is a gradient of surface tension at the interface between two phases, flow moves from areas of low surface tension toward ones of high surface tension. Such as the wind, a strong convective motion at the surface by a shear stress may be produced (Davidson, 2004).

Figure 3.10: Two-dimensional turbulence showing a schematic of the flux lines (Davidson, 2004).

Mathematically, non-linear and chaotic nature of the flow of fluids has equations which interpret and analyse. However, these equations are not able to provide a general solution. Hence, there is no clear definition of every kind of flow. It is hard to consist the properties of flows such as showing a random variation in space and time, the wide range of scales, three-dimensional nature or diffusiveness with momentum, mass and temperature. Simplified turbulence models as done in computational fluid dynamics are used to model the flow motion.

Mentioned distributions can be defined with two different approaches such as Eulerian and Lagrangian methods (Figure 3.11). Eulerian frames of reference are used to objectify complex physical phenomena. The fluid travels between cells of fixed mesh and this movement is viewed orthographic projection. In certain moments, a series of still "pictures" can develop, and since every picture refers back to the same coordinate system, behaviour can be tracked. Rather than being idealized, Lagrangian frames of reference are premised on unce1tainty and variability. The coordinate system moves and follows the shape of the interface, so that origin not at a point fixed in space, but at the centre of the subject. The frame is thus always subjective. Lagrangian frames present simultaneous possibilities instead of as a linear march in which there can only be one position for each moment of time (Addington, 2007).

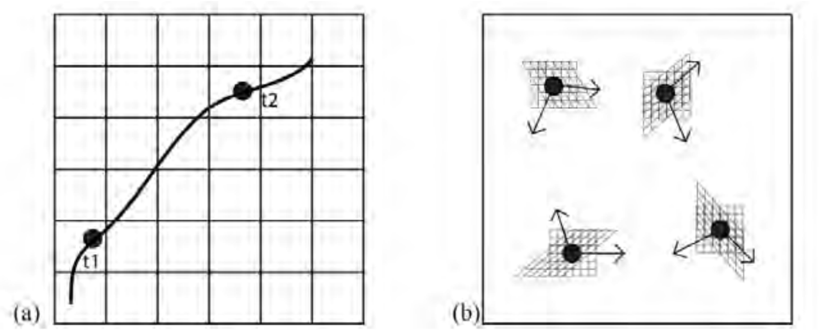


Figure 3.11: Diagrams of (a) Eulerian and (b) Lagrangian methods.

By the evolving computational and numerical algorithms for the neighbouring sequences, it has become possible to simulate millions of particles with a processor. In recent years, *Discrete element method* became an effective tool for analyzing the problems in the engineering field of intermittent and granular materials. Simulation softwares using this numerical method for modelling the dynamics of solid particles, calculates the position, velocity, contact forces for each individual particle. firstly, simulation detects the contact points and calculates interaction forces between the particles (Figure 3.12). The resulting forces apply to the centre of particles to move. At each numerical iteration step, velocity and acceleration are updated. The most important feature of discrete element method is the modelling of the interactions of a large number of elements without excessive memory requirements (Luding, 2008).

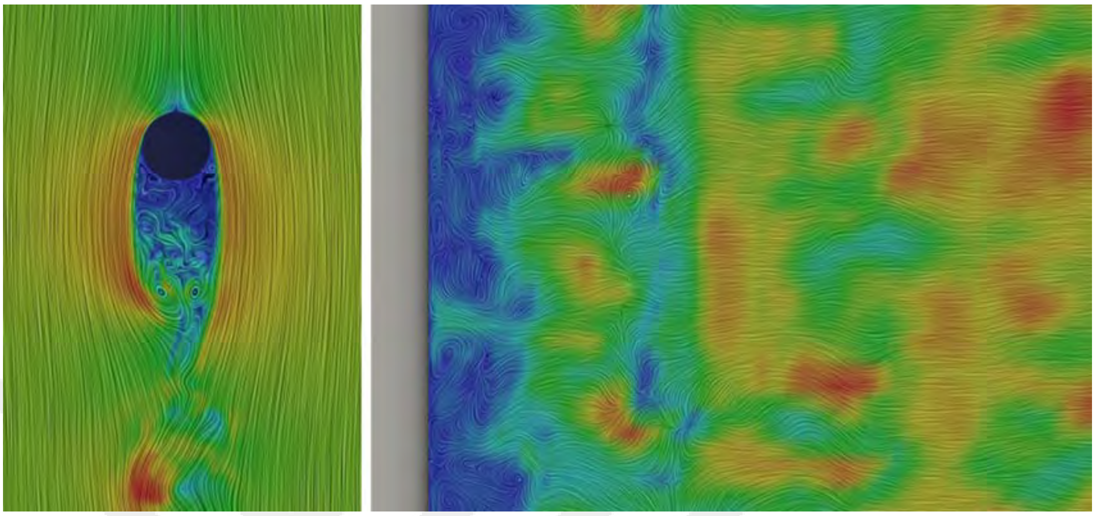


Figure 3.12: Simulations of turbulent flows (Url-15).

3.3 Subjectivity

> Order and chaos, simplicity and complexity, the mechanical and the organic, aren't necessarily at opposite ends of a spectrum. They're symbiotic, intertwined. Any line we might walk between the two is a knife edge. Our very existence is poised between entropy and order (Pearson, 2011, p. 27).

Algorithms and their outputs are like order and chaos, they both are codependent and need each other. Describing a work as generative expresses a process free of control and this generative process needs algorithms to appear. Algorithms are step by step instructions for producing or accomplishing things. Like a recipe turning basic ingredients into a cake, an algorithm is a rules-based system that receives and puts, performs steps and produces outputs. For instance, rule cycle (or order) of an algorithm might be: First, create a box; second, copy, rotate, and scale; then repeat the process all over again. Definitely, parameters are the changeable drivers of an algorithmic the system. Changing the parameters of a system can vary the design results, sometimes dramatically different results from one to next. For the previous algorithm, with changing the parameters such as the number of the times to repeat or position of the axes of the rotation, the algorithm can begin to produce an enormous amount of information (Figure 3.13).

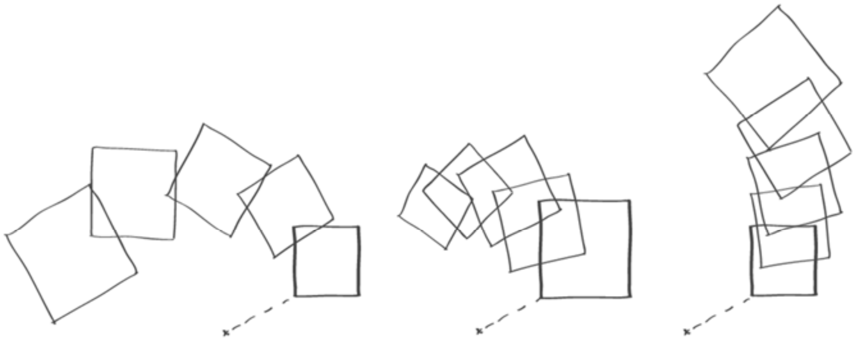


Figure 3.13: Changes due to using different parameters in an algorithm.

The notion of predictability is associated with the human control. Traditionally, designer has the full control of their design work. Design decisions are made by the understanding and interpretation of designer who owns the control every step of design process. However, creating algorithmic forms may go over the expected virtual representations of ideas. Algorithms may give outcomes of probability, or complexity, sometimes purely unimaginable.

As like *Schotter*, computer graphic from the 1960s produced by a structured operation by random generators, the simple instructions may lead the drawing to the discovery of new images (Figure 3.14). Traditionally, accumulative progression during design processes is the main logic. tın order to compose elements into objects designers work in a bottom-up approach. In algorithmic design, constructive combinations, integrations, linkages, bifurcations are can be used as concepts so that the images turn out at the unpredictable edges of visual creativity. The effects of change can be visualized in relatively short times, compared to the time the single tool to create a visual was hand drawing (Figure 3.15).

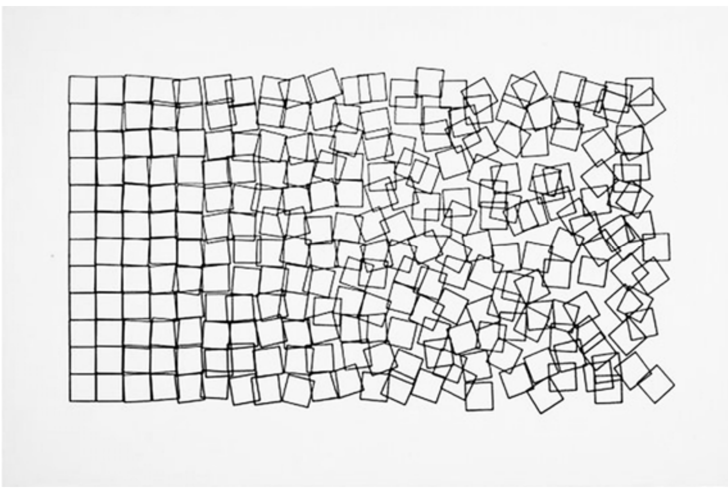
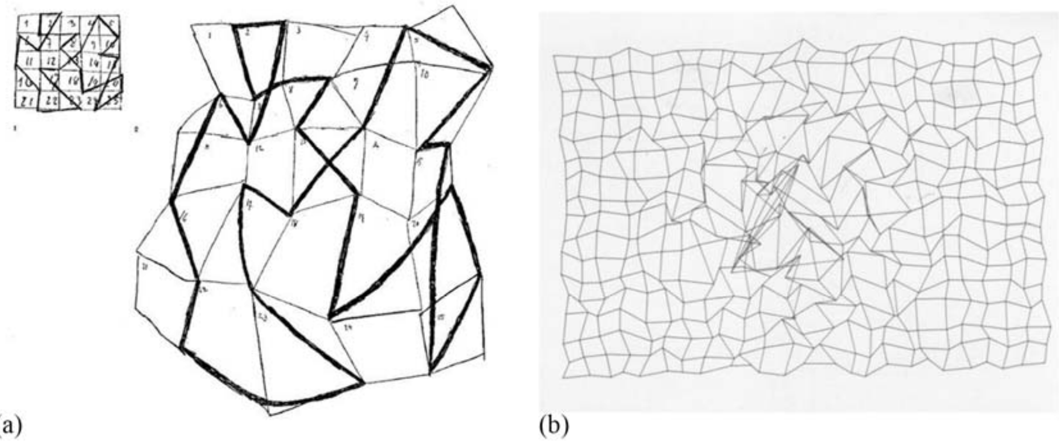


Figure 3.14: Schotter, Georg Nees (Url-16).

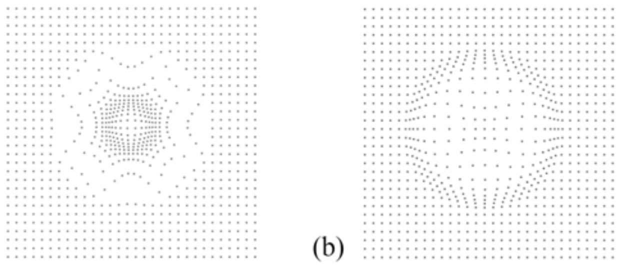


(a) (b)

Figure 3.15: (a) Uneven surface sketch (Klee, 1956, p.255) (b) Turbulence centred, Georg Nees, 1965-1968 (Url-16).

3.3.1 Attractors

Attractors are virtual magnets which are imagined and programmed points in space that either attract or repel other objects. As with magnets, the closer the objects are to the attractor, the more strongly they are attracted to it (Figure 3.16a). Attractor functions iteratively, meaning that with each calculation step, the velocity vectors of all the objects within a defined radius around the attractor are modified so that they move towards it. Obviously, if negative strength value is used, attractor repels (Figure 3.16b). This occurs as measuring the distance between the object and the attractor, then defining a function to calculate the attractive force and applying the force to the object's velocity vector, the structure starts to be deformed.



(a) (b)

Figure 3.16: (a) The pull and (b) push effects of an attractor.

Attractor function is time-based, each time a program is iterated, the function makes a minimal effect on the environment. Forms gradually emerge that can not be generated any other way or only with great difficulty (Bohnacker, 2012). They are also useful when a large number of objects are to be gathered in one place or kept away from a space as seen Eno Henze's *Der wirklichkeitsschaum* (Figure 3.17).

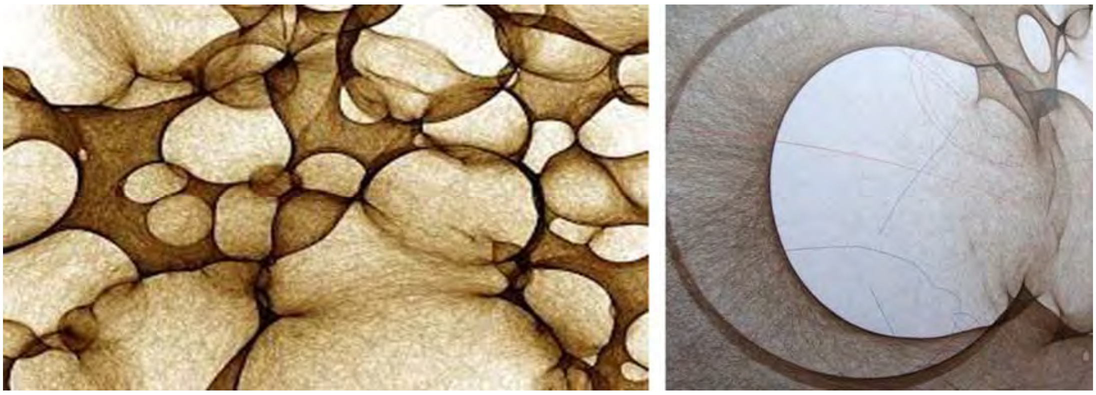


Figure 3.17: Der wirklichkeitsschaum, Eno Henze (Url-17).

3.3.2 Randomness and noise

The term, *random* usually signifies an unpredictable event. A random generator created with the help of a computer, however, will never be able to create truly random events or actions because the seemingly random sequence of numbers has been generated by an algorithm (Figure 3.18a). This is called determinism in computer science, meaning that the sequence of values is determined by the initial condition. The random command generates an identical sequence of values when working with the same random generator. In many programming languages, the initial condition is set unnoticed in the background, thereby creating the illusion that real random values are created each time the program started.

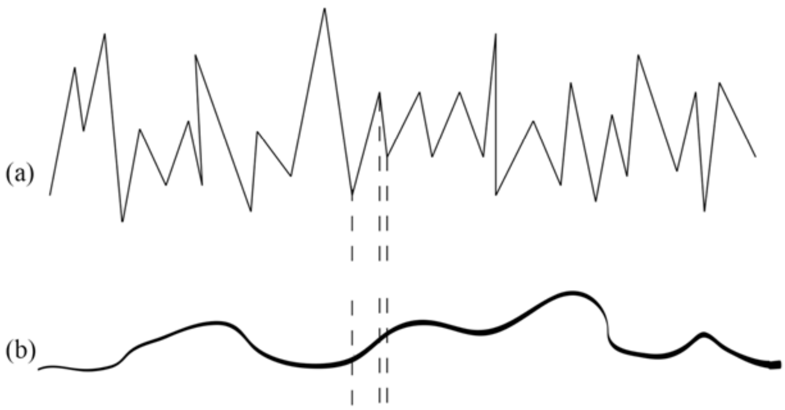


Figure 3.18: Representation of y-coordinate under (a) random and (b) noise function.

Using computer as an idea generator notion of randomness, complexity can be defined, codified and tested. Random generators simply reproduce or sets a specific sequence of random values, however, this is not sufficient to mimic natural phenomena such as clouds, water mountains, hair, smoke, etc (Figure 3.19a). The random generator

“Perlin noise” is needed to produce these kinds of effects (Figure 3.18a). Perlin noise generates sequences of values with smooth transitions and the values increase or decrease in a seemingly natural way (Figure 3.19b). Randomness in algorithms can produce unpredictable results. But as Terzidis (2006) states:

> Unlike chaos, a random rearrangement of elements within a rule-based system produces effects that, although unpredictable, are intrinsically connected through the rules that govern that system. In the field of design, similarities may exist on formal, visual, or structural levels (p.21).

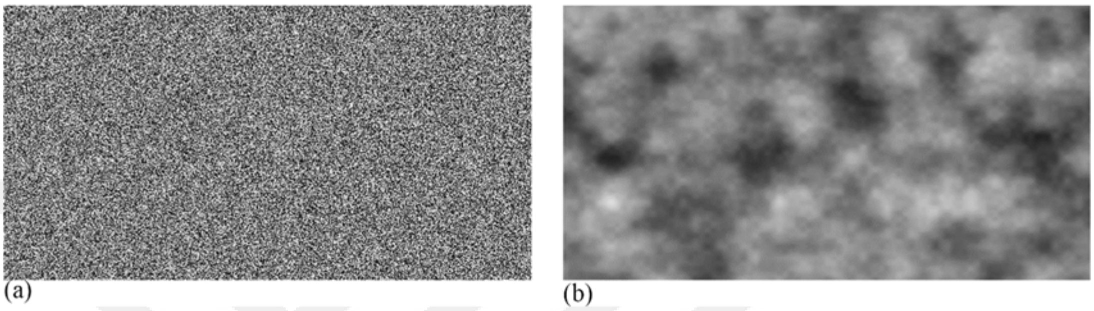


Figure 3.19: Texture from (a) randomness and (b) noise (Bohnacker, 2012).

An algorithm which applies variables chosen randomly so as to provide multiple solutions and flexibility may create complexity due to the fact that any deviation from an orderly placement creates randomness. The notion of random process innate to the ability to involve unpredictable events resembles natural processes. Eno Henze’s Ambush series is created by Perlin noise function which is superimposed noise of various frequencies (Figure 3.20). It creates random structures similar to those of a natural phenomenon such as a water surface with waves of different sizes.

Figure 3.20: Ambushes, Eno Henze (Url-18).

The random or noise values may be used in different ways such as to colour objects, to set the height position of the points in a grid, or to control the movement of a swarm of agents. Via changing the height position of the points in a grid, pseudo-realistic landscapes, water or clouds can be represented (Figure 3.21).

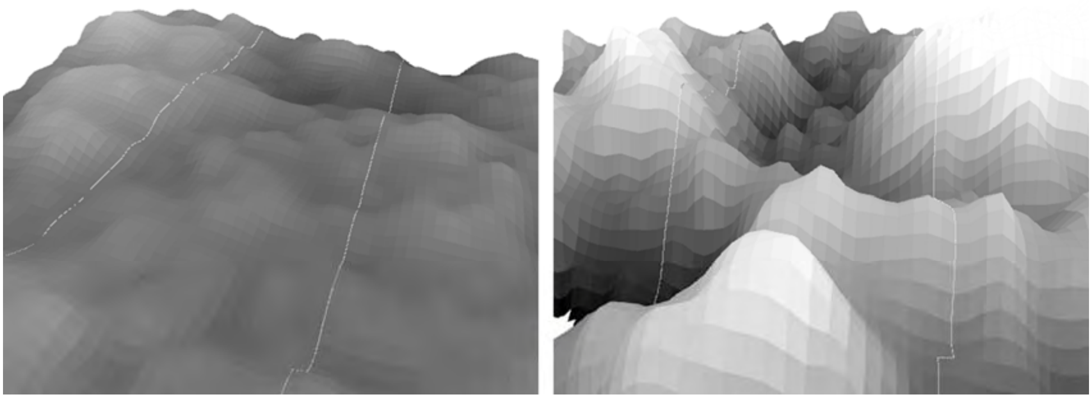


Figure 3.21: Pseudo landscapes generated by Perlin noise argument.

In order to animate swarm of agents, noise functions are used to assume the positions of agents. The positions of the agents are uploaded and drawn in each frame iteration. The three-dimensional noises can be thought of as a large cube of random numbers in which the individual values differ only slightly from their neighbours. If the agents move in the area, but the random numbers for their movement are selected from different layers of the random number cloud, they are no longer bound to the same paths. The closer the z-coordinates lie to each other, the more they cluster together. The image becomes even more dynamic when the z-coordinates are changed slightly and continuously. As an example, Kokkukia uses the emergent capacities of Swarm Intelligence as an urban design methodology at their proposal for the Melbourne Docklands. The self-organisation of structures and the interaction of autonomous agents creates an emergent behaviour by using algorithm as an urban design tool and generates a complex urban system (Figure 3.22).

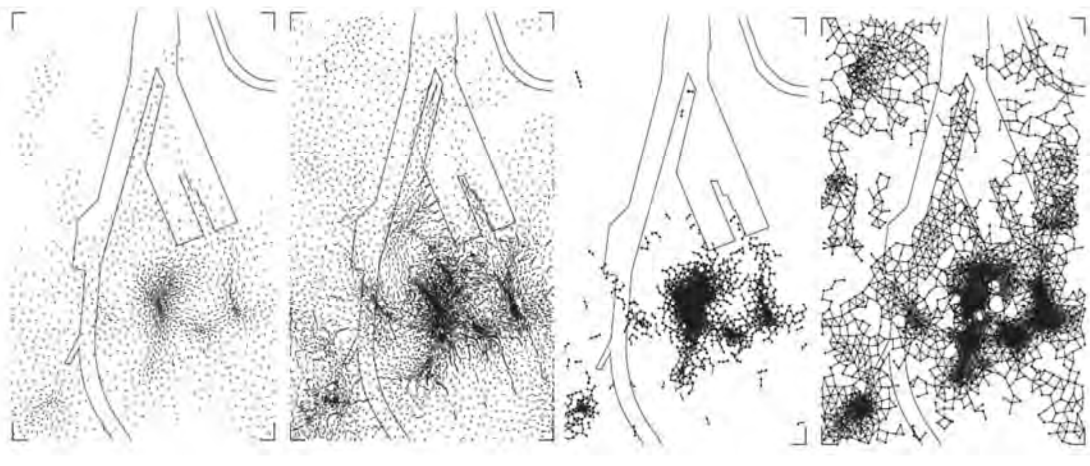


Figure 3.22: Swarm urbanism, Kokkugia (Url-19).

3.3.3 Morphing

Mathematically, generating three-dimensional objects like spheres, cylinders, or other complex forms is simple tasks. However, a two-dimensional grid of points is not easily definable. Morphing is a formalistic approach that has both change and stability. The relations change during transformation. According to Terzidis (2006):

> An initial shape A can be transformed to a target shape B by applying any number of in-between steps. All the points of shape A are mapped onto shape B and vice versa. Furthermore, once the rules of transition have been established, the transition can be allowed to continue extrapolating beyond its target (p.50).

In order to transform two-dimensional planes into three-dimensional planes, a mathematical formula has to be applied to each point (Figure 3.23). Obviously, even though the same formula is used different value ranges that used in the formula generates different shapes (Figure 3.24). Generating a number of grids and displaying them to an arranged mesh and changing the mesh to define new forms is also gives many flow-like forms (Figure 3.25).

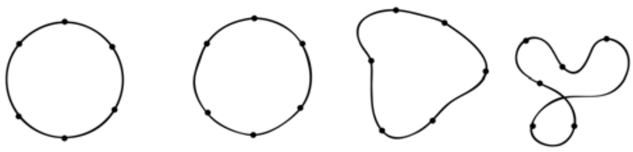


Figure 3.23: Deforming of a circle.

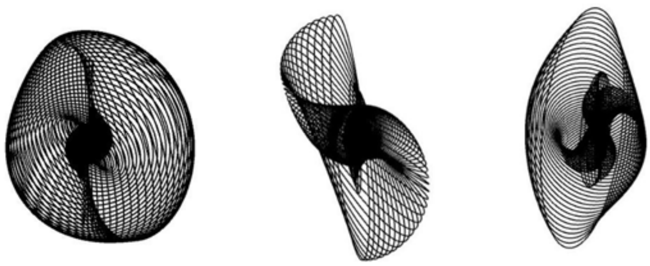


Figure 3.24: Formulated shapes from the same formula.

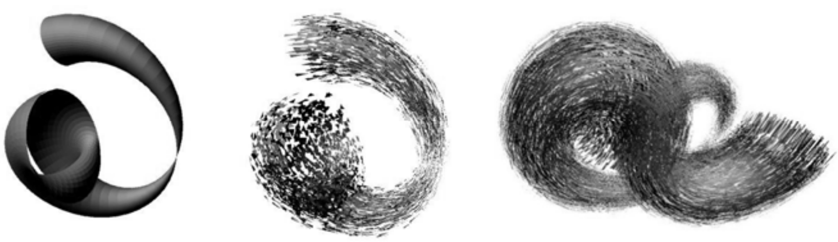


Figure 3.25: Formulated shape and the deconstructed meshes.

3.4 Flow Conception in Between Objectivity and Subjectivity

An attempt that to create a perception of nature can extend it to a new series of creative experiences. For instance, in science, testing some perceptions, experiments and observations can open up the unfoldment of notion and creativity. In lateral means, imagination means “the ability to make mental images” which imitate the forms of real things (Bohm, 1987, p.273). The creative inception of new forms is experienced as both visual images and sorts of feelings, tactile sensations and kinesthetic sensations. In a way, when imagination gets an output (a result), it makes that “imaginary” relatively fixed for a moment. Even though science and art seem to have a rigid separation between them, recent works show that they come into a middle ground and create many rich possibilities by involving each other.

At the end of the 19th century, many scientists did recordings to observe movements of air. Scientific observations, recorded through photography (chronophotography), would help to understand how a liquid reacts to the passing of an object. Beside other scientists, Etienne-Jules Marey made many experimental shots of a steady stream of smoke within a closed device with transparent walls with some different shaped or angled surfaces on the path of the smoke (Figure 3.26). The experiments were to explain aerodynamics or propelling in fluids, ventilation, all things related to movements of air.

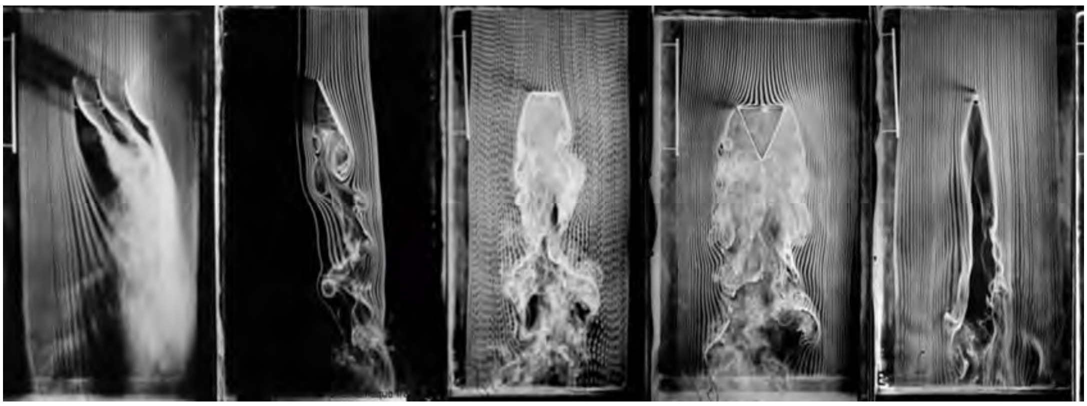


Figure 3.26: Smoke, Etienne-Jules Marey (Url-20).

György Kepes's works to unify science conceptions are still inspiring. As first pivotal attempts to integrate the disciplines such as arts and science, in a time when there is no animation software, the works of Kepes are on simulated effects, better described as motion pictures, and photography of lights and objects under various illumination conditions (Figure 3.27).

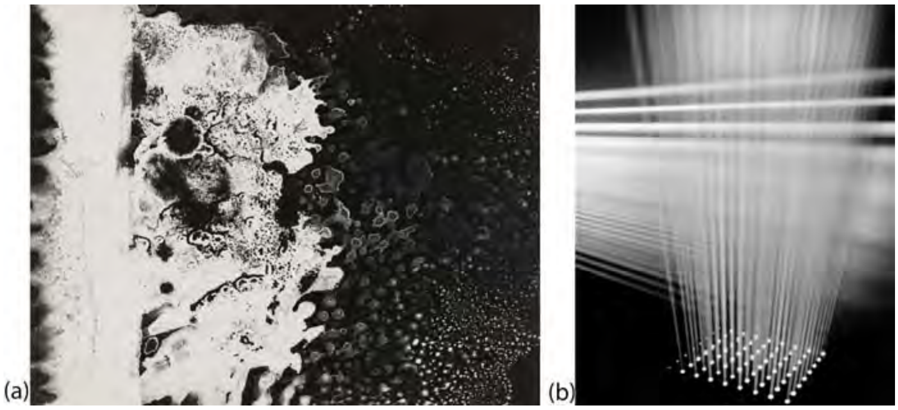


Figure 3.27: (a) Abstraction: Surface tension #2, (b) luminous wall, György Kepes (Url-21).

In the1960s, Desmond Paul Henry invented the mechanical analogue computer, originally operated by two electric servo-motors and air-pressure. Drawings are produced by combinations of pen-movement and table-movement. The pen is moved in elliptical paths of various dimensions, and the harmonic table-movements distort the ellipses at selected points, at the same time shifting the paper in a curved path. The method of paper-shifting and ellipse distortion is such as to introduce varying degrees of randomness into the designs, thereby ensuring that no two are exactly alike (Figure 3.28).

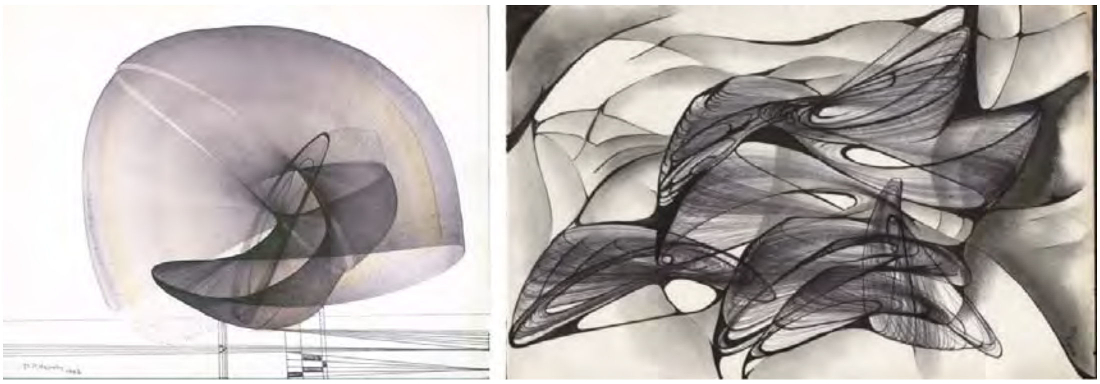


Figure 3.28: Drawings produced by the Henry Drawing Machine (Url-22).

In the architectural field, design is considered as the organization of materials that controls and arranges energy flows. As a whole, it is an energetic organization that balances and sustains material forms, concurrently and indivisibly. Though matter and energy are divided for identification, they are indistinguishably connected (Fernández-Galiano, 2000). 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. high-resolution thermal camera shoots (Figure 3.29) 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 (Url-26). 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 (Lally, 2007). Lally highlight that people feel safe when they enter an area which is restricted by the light, even though there is no physical obstacle. An interactive installation, *Transcending Boundaries* (Figure 3.30) can be exemplified, which leads the audience to perceive and question the limit of space by only differentiating the qualities of light.

Figure 3.29: ORA, Philippe Baylaucq (Url-23).

Figure 3.30: Event-based visualization, teamLab (Url-24).

In a similar manner, in 1993, long before the digital devices used in teamLab's or Baylaucq's works, Olafur Eliasson made an installation which is a curtain of fine mist, projected by a spotlight (Figure 3.31). In a darkened space, a rainbow can be seen in the falling water from certain perspectives. The view of rainbow disappears or shifts in intensity by the position of the viewer. Eliasson focuses on the "production of atmospheres" in his artworks. His stage-setting artworks are to actualize the atmosphere real-time embodied image via lightings.

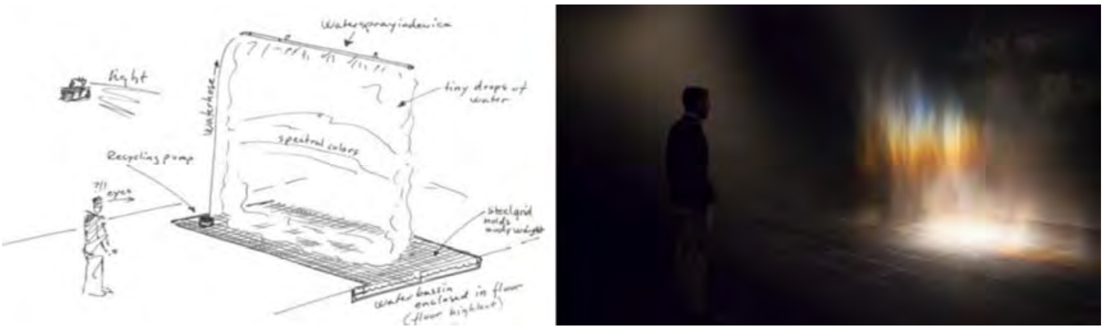


Figure 3.31: Beauty, Olafur Eliasson (Url-25).

As another prototype, Philippe Rahm's *Gulf Stream* (Figure 3.32) creates a thermal space via the movement of air using the natural phenomenon of convection, in which rising hot air cools on contact with the upper cool sheet and, falling, is then reheated on contact with the hot sheet, thus simultaneously, creates a constant thermal flow akin to an invisible landscape. Rahm states that instead of structuring architecture on a current of air, he opens up a fluid, airy, atmospheric space and generates a landscape of heat (Rahm, 2008).

Figure 3.32: Gulf Stream: Simulation and Venice Biennale installation (Url-26).

4. INTERPRETATIONS OF FLOW ALGORITHMS

Interpreting of concepts and defining the conditions of flow conceptualize the dynamic render of possibilities. According to Bachelard's general approach to the nature of science, scientific objects are "technically produced in a continuous process of assemblage, rectification, and repetition" (Rheinberger, 2010, p.12). All scientific events do not have to be taken from nature since technology produces its own nature. Yet, the process is a "recursion" which both the scientific object and the knowledge are nested. Science itself is now a "phenomenonotechnique". In other words, technique produces phenomena. This phenomenological structure of the digital may reproduce novel perceptions. Now the virtual and the real combine to create the digital reality. Our scientific knowledge must include a never-ending restructuring and correction process. This requires a new conceptual repertoire of knowledge production analysis combining *experiment* and *observation*.

4.1 Methodology

In this chapter of the thesis, to explore the potentials of the conceptual and phenomenological properties of flow, algorithms will be investigated and examined through the experiments. Under the titles of concepts related to flow, algorithms and simulations with the production processes of the two and three-dimensional images generated in the digital environment with selected techniques will be presented. The flow metaphor was sought to be based on a behavioural basis by investigating how a non-mechanical motion understanding could be produced in a computer environment through simulated tools and models in the design process. Algorithmic "abstraction" will be made in Java-based "Processing" with various explorations providing a conceptual image. The animated (looped) series have made to precisely choreograph the development of the process. In order to explore the potential of the algorithms, the understandings of the relation between the elements and techniques have presented. In order to generate variations of fluid behaviour, Autodesk CDF is used as a computational fluid dynamics software. Physical model experiments were carried out to analyze the concepts of motion and transformation depending on time, and the motions of liquids were experimentally tried to be defined.

4.2 Flow Fields

Vector field is a function that has variation and a way of visualizing functions that have the same number of dimensions in their input as in their output each individual input point. A variation is a multivariable real number function which converts a point into a new point. As a whole class of functions, variations have external parameters needed to get a specific function so that in a different function, a different set of parameters will be given as results. Simply, if the decision; to have every vector in the flow field pointing to the right (Figure 4.1a), to point in random directions (Figure 4.1b), points towards the centre (Figure 4.1c), or a 2D Perlin noise (Figure 4.1d):

(a)
```
for (int i = 0; i < cols; i++) {
for (int j = 0; j < rows; j++) {
field[i][j] = new PVector(1,0);}}
```
(b)
```
for (int i = 0; i < cols; i++) {
for (int j = 0; j < rows; j++) {
field[i][j] = PVector.2D(); }}
```
(c)
```
PVector v = new PVector(x,y);
v.here();
field[i][j] = v;
```
(d)
```
float xoff = 0;
for (int i = 0; i < cols; i++) {
float yoff = 0;
for (int j = 0; j < rows; j++) {
float theta = map(noise(xoff,yoff),0,1,0,TWO_PI);
(...)}(Url-27)
```

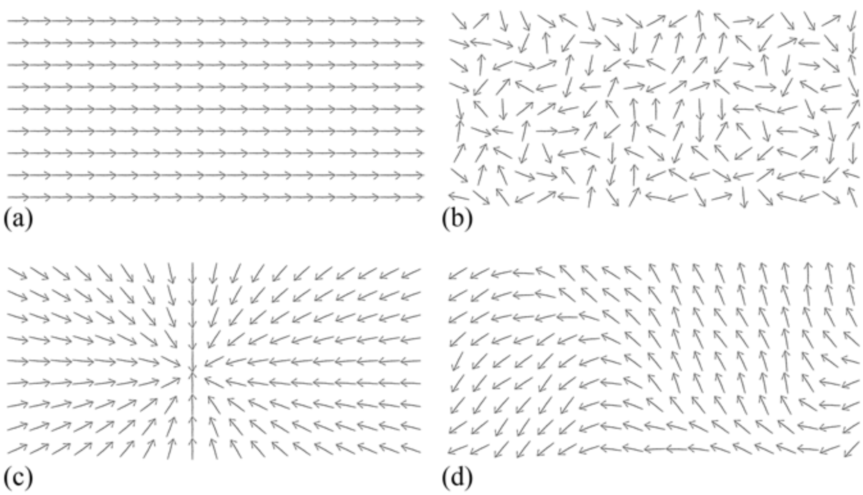


Figure 4.1: Vector fields variations.

If it is imagined droplets of water flows instead of arrows and describe that flow mathematically, it is needed to look at every given point the particles moving in some different ways.

```
ArrayList<PVector> points = new ArrayList<PVector>();
(…)
void setup() {
(…)
for (float x=-3; x<=3; x+=0.07) {
for (float y=-3; y<=3; y+=0.07) {
PVector v = new PVector(x+randomGaussian()*0.003,
y+randomGaussian()*0.003);
points.add(v); }}}
void draw() {
(…)
float xx = map(p.x, -6.5, 6.5, 0, width);
float yy = map(p.y, -6.5, 6.5, 0, height);
PVector v = new PVector(0, 0);
(…) }(Url-28)
```

Assigning a vector to describe the motion of each fluid particle at each different point gives a vector field (Figure 4.2). Each of the point moves along a vector from the vector field and trace lines build the resulting image. The field vector changed to a constant variable such as (0.1,0.1).

```
PVector v = newPVector(0.1, 0.1);
```

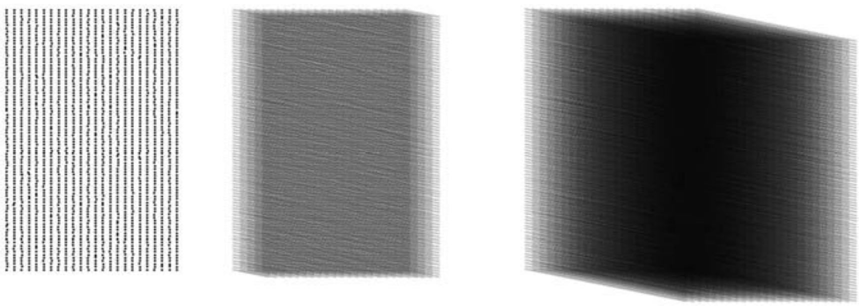


Figure 4.2: Points as droplets of water abstraction and the movements of points along vectors.

Flow-lines which create visual pathways generates forms and increase the visual momentum of the design work. Lines has the ability to create an virtual chaos and emergence of a new being. Applied with forces, lines change direction or get broken or split and tend to give dynamic images (Figure 4.3). These linear flows indicate possibilities as they exhibit metamorphic thresholds. By the range noise function (value from 0 to 1) and the point's position, the variables of scale and strength of the noise are calculated by the angle properties [sin()/cos()] in polar coordinates.

```
float n = TWO_PI * noise(p.x,p.y);
PVector v = new PVector(cos(n),sin(n));
```

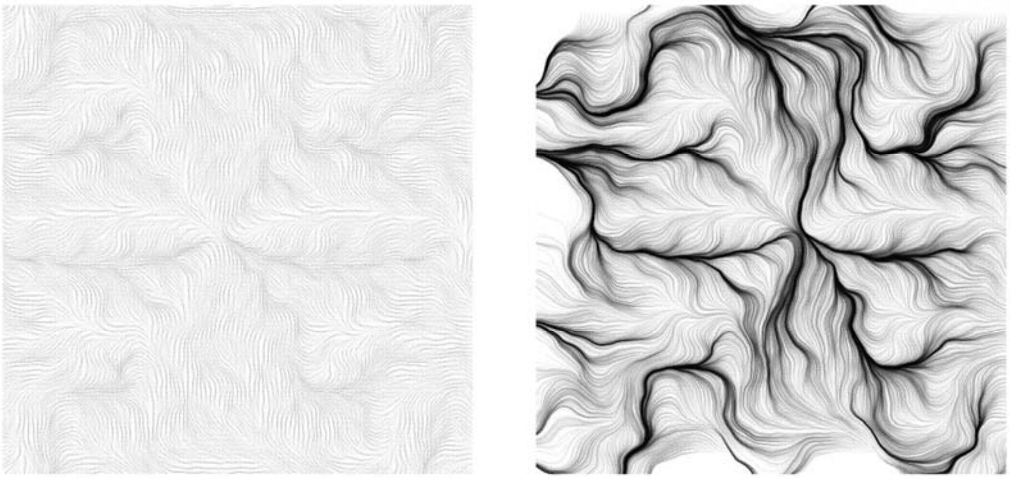


Figure 4.3: Perlin noise field generation.

If the scaled to range [-1.1] noise is multiplied by different values such as 10, 100, 400 or 1200 (Figure 4.4, 4.5):

```
floatn = 10* map(noise(p.x/5,p.y/5),0,1,-1,1);
PVector v = newPVector(cos(n),sin(n));
```

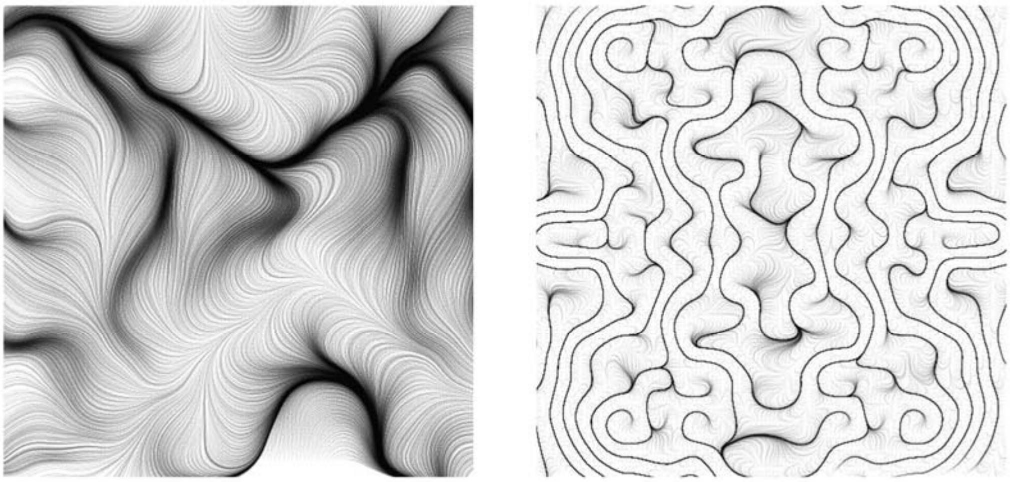


Figure 4.4: 10 and 100 times scaled noise fields.

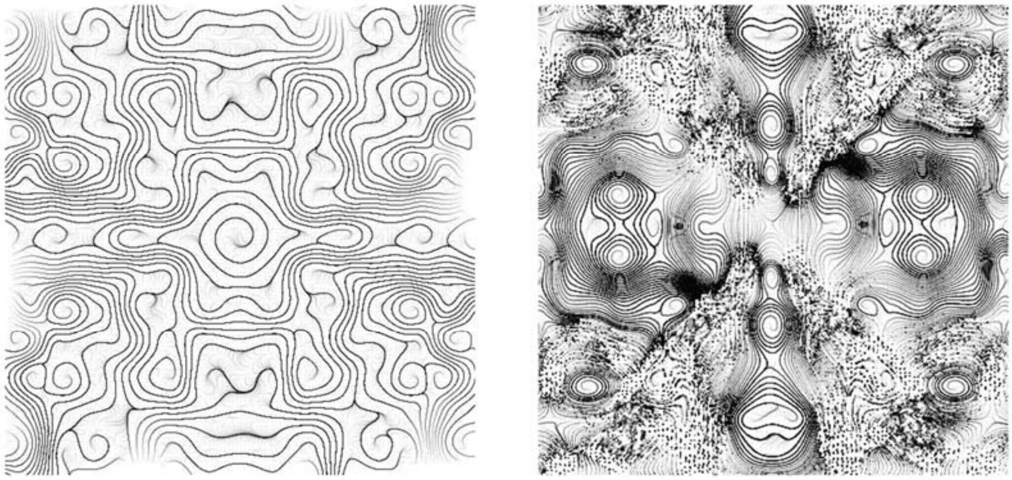


Figure 4.5: 400 and 1200 times scaled noise fields.

If the length of vector is changed by scaling the input coordinates (Figure 4.6):

```
floatn = 5*map(noise(p.x,p.y),0,1,-1,1);
PVector v = newPVector(n,n);
```

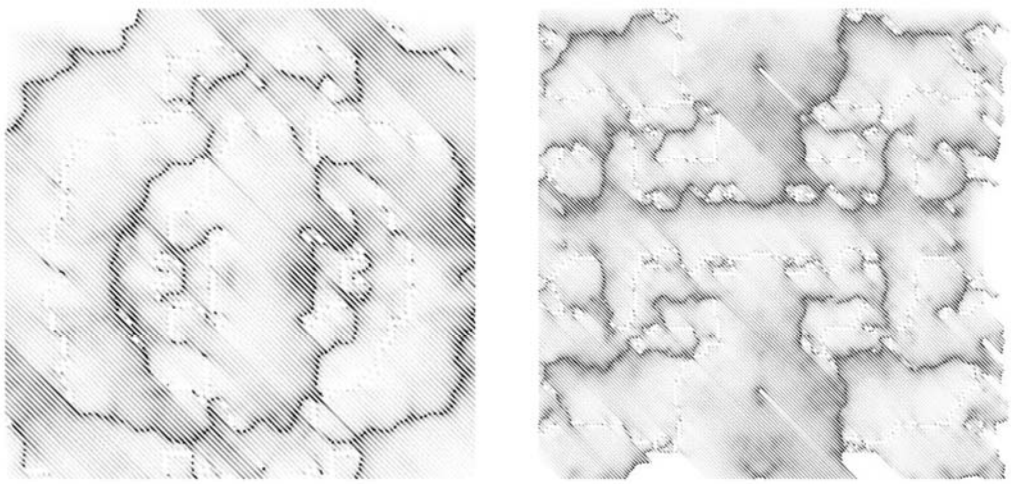


Figure 4.6: Noise fields by scaled input coordinates.

A parametric curve function is used to convert noise() and the noise scale is changed (Figure 4.7):

```
floatn = 2*map(noise(p.x,p.y),0,1,-1,1);
floatsinn = sin(n);
floatcosn = cos(n);
floatxt = sq(sinn)*sinn;
floatyt = sq(cosn)*cosn;
PVector v = newPVector(xt,yt);
```

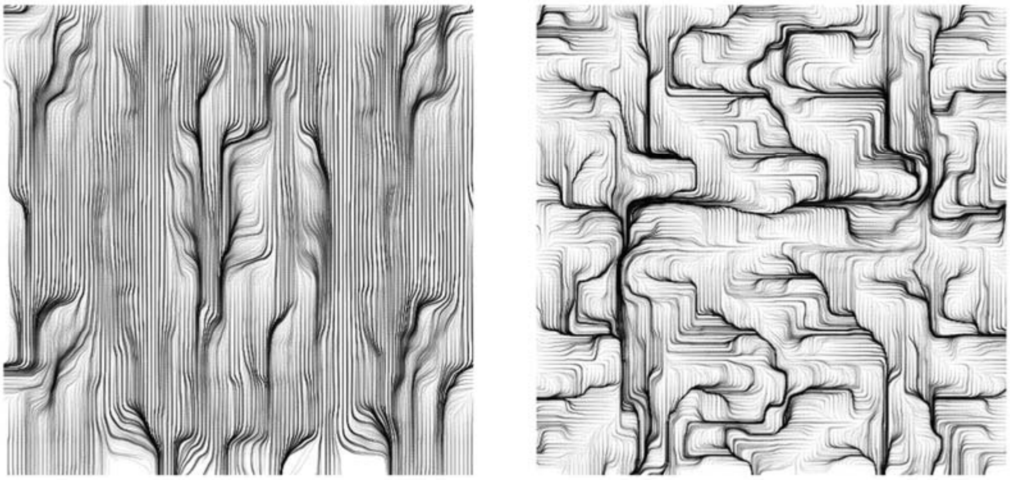


Figure 4.7: Noise fields by curve function.

Points that moves with vectors out of variable noise functions can give a flowing water result (Figure 4.8):

```
PVector v1 = vexp(p,1);
floatn1 = map(noise(v1.x,v1.y,time),0,1,-1,1);
floatn2 = map(noise(v1.y,v1.x,-time),0,1,-1,1);
PVector v2 = vexp(newPVector(n1,n2),1);
PVector v = newPVector(v2.x,v2.y);
```

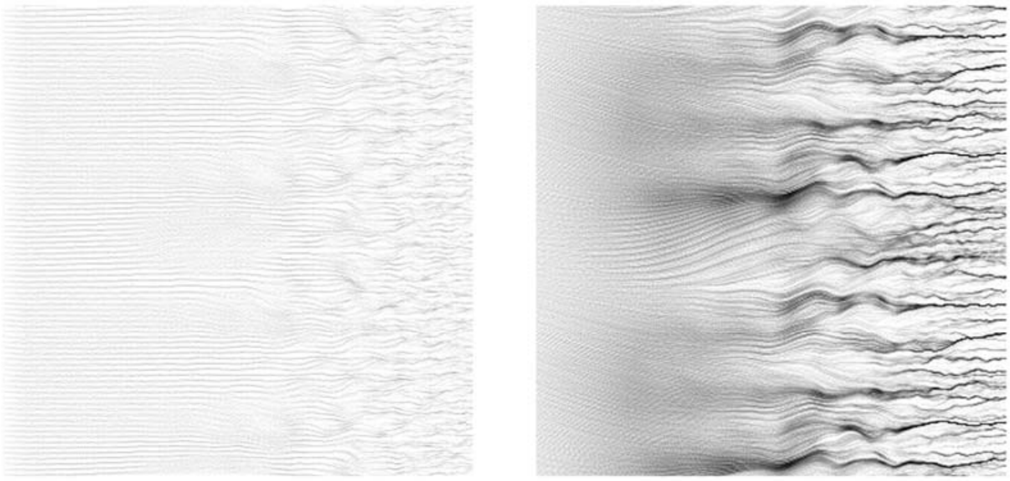


Figure 4.8: Horizontally moving points field.

All above operations can be used to generate flow fields, flow-lines as contours show a direction of movement and can be used to follow the fluid exterior lines of a form.

4.3 Multiplicities

Multiciplity is defined by variations and derives from folding or twisting of elements. The variations as simple remappings of a plane can be dependent on a function that defines the behaviour of the variation. Applying a transform to a set of coordinates involves transformation to the coordinates and a variation function can be applied to the transformation. This lets to change the coordinate systems of the variations. Calculation of a simple identity function is drawn as a grid (Figure 4.9a):

```
void draw() {
if (go) {
for (int i=0; (i<20)&go; i++) {
for (float x=x1; x<=x2; x+=step) {
drawVariation(x, y);}
y+=step;
void drawVariation(float x, float y) {
float xx = map(x, x1, x2, 20, width-20);
float yy = map(y, y1, y2, 20, height-20);
point(xx, yy);} (Url-28)
```

A sinusoidal function drawing can be started with linear folding (Figure 4.9b):

```
void drawVariation(float x, float y) {
PVector v = new PVector(x,y);
float amount = 3.0;
v = sinusoidal(v,amount);
float xx = map(v.x+0.003, x1, x2, 20, width-20);
float yy = map(v.y+0.003, y1, y2, 20, height-20);
point(xx, yy);}
PVector sinusoidal(PVector v, float amount) {
return new PVector(amount * sin(v.x), amount *
sin(v.y));}
```

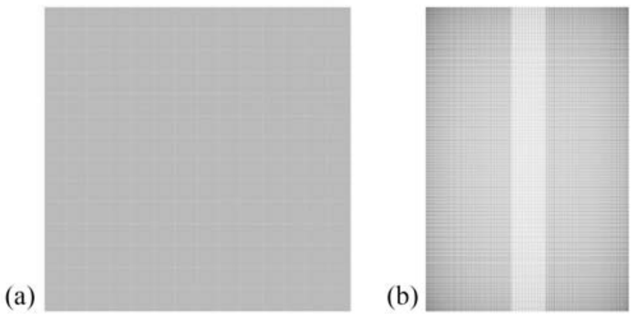


Figure 4.9: The grid of floating point values and linear folding.

If a curve function which uses polar coordinates to calculate x and y is applied to vectors with different angles (Figure 4.10):

```
PVector curvefunc(PVector v, float amount) {
float r = v.mag() + 1.0e-10;
float theta = atan2(v.x, v.y);
```

```
float x = 8*amount * sin(theta) / r;
float y = amount * cos(theta) * r;
return new PVector(x, y);}
```

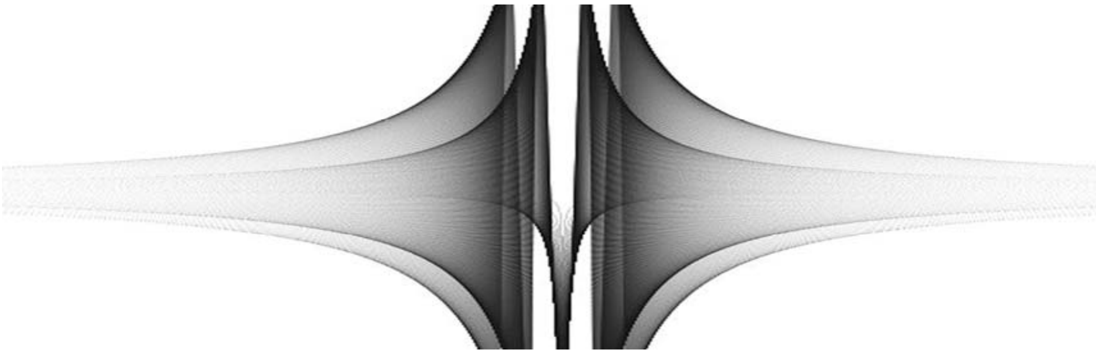


Figure 4.10: Curve function generated fold.

A curve is generated by a mathematical function and defines the probability of any given value occurring as a function of the standard and mean deviation. The output of the sine function is a curve which had the behaviour known as oscillation, a periodic movement between two points. Different sine values vary the formed curves and create attractive forms with the oscillation curves. The shape of the oscillations are changed by different frequencies and this expands the varying range of forms that are generated. If the case is a Lissajous curve (Figure 4.11):

```
void calculateLissajousPoints() {
lissajousPoints = new PVector[pointCount+1];
for (int i=0; i<=pointCount; i++) {
float angle = map(i, 0,pointCount, 0,TWO_PI);
float x = sin(angle * freqX + radians(phi)) * cos(angle
* modFreqX);
float y = sin(angle * freqY) * cos(angle * modFreqY);
x = x * (width/2-30);
y = y * (height/2-30);
lissajousPoints[i] = new PVector(x, y);}}

void drawLissajous() {
(…)
for (int i1 = 0; i1 < pointCount; i1++) {
for (int i2 = 0; i2 < i1; i2++) {
PVector p1 = lissajousPoints[i1];
PVector p2 = lissajousPoints[i2];
d = PVector.dist(p1, p2);
a = pow(1/(d/connectionRadius+1), 6);
if (d <= connectionRadius) {
stroke(lineColor,  a*lineAlpha);
line(p1.x, p1.y, p2.x, p2.y);}}}} (Url-29)
```

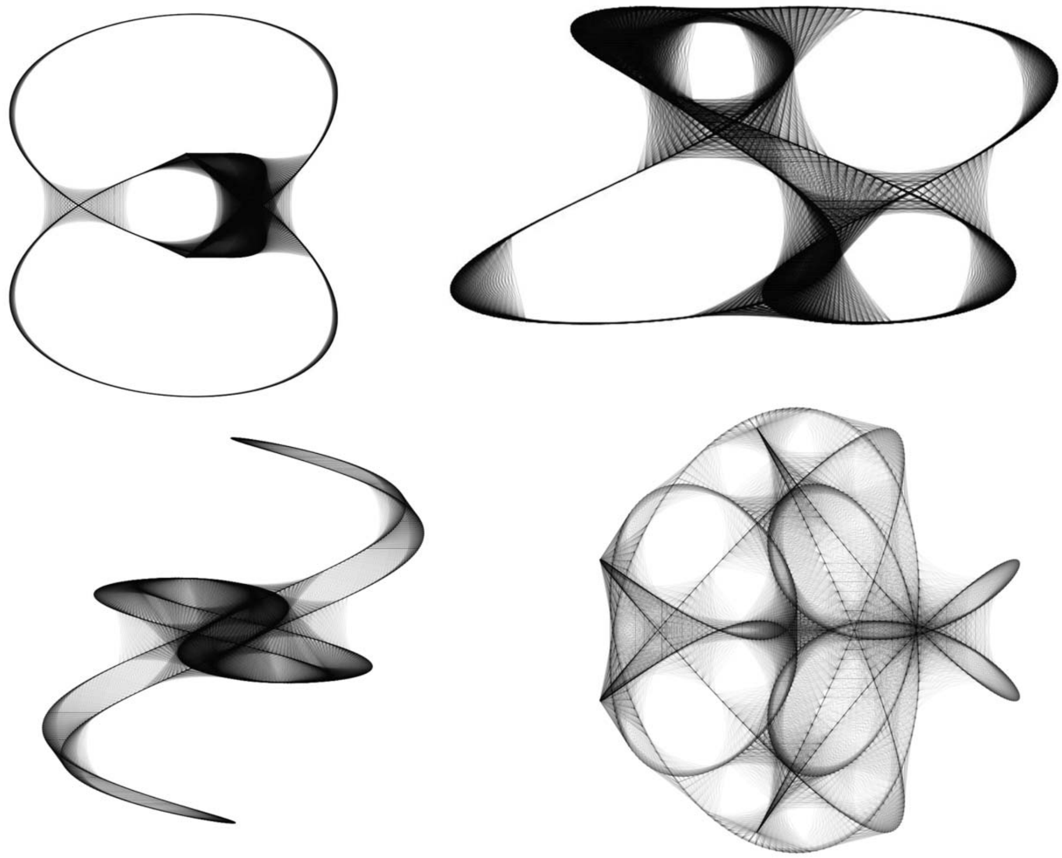


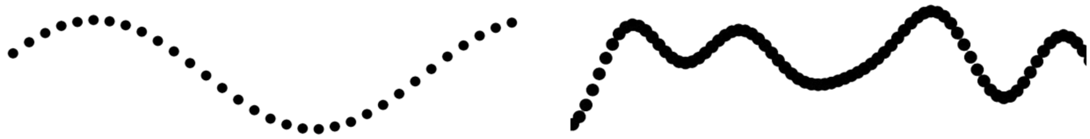
Figure 4.11: Lissajous figures with all points connected.

To simulate a soft surface such as water a wavy pattern could be used. According to a precise period of the wave, some simple oscillations could be computed. In order to move the wave, a variable dedicated to tracking different angle value with its own angular velocity each frame is needed (Figure 4.12a):

```
void draw() {
(…)
startAngle += 0.015;
float angle = startAngle;
for (int x = 0; x <= width; x += 24) {
float y = map(sin(angle),-1.2,1.2,0,height);
(…)
angle += angleVel;}}(Url-30)
```

By changing the values of multiple waves, complex waves can be produced (Figure 4.12b):

```
for (int j = 0; j < maxwaves; j++) {
float x = theta;
for (int i = 0; i < yvalues.length; i++) {
if (j % 2 == 0)  yvalues[i] += sin(x)*amplitude[j];
else yvalues[i] += cos(x)*amplitude[j];
x+=dx[j];}}}
```



(a) (b)

Figure 4.12: Wave generation.

The grid of points in the two-dimensional plane can be “a bent” to form the closest areas. In order to draw such grid the most efficient way is to arrange the points in a regular grid. The x and y values are used to find the value for z-position and the function generates a wave-like shape when it combined with the sine function (Figure 4.13).

```
void draw() {
(…)
translate(width/2, height/2);
float ynoise = ystart;
for (float y = -squaresize; y <= squaresize; y+=3) {
ynoise += 0.02;
float xnoise = xstart;
for (float x = -squaresizeX; x <= squaresizeX; x+=3) {
colorMode(0);
d = map(sin(0.02*dist(width/2+x, width/2+y, width/2,
height/2) - TWO_PI*time), -1, 1, .5, 1);
float f = map(sin(0.02*dist(width/2+x, width/2+y,
width/2, height/2) - TWO_PI*time), -1, 1, 0, 150);
(…)}}}
```

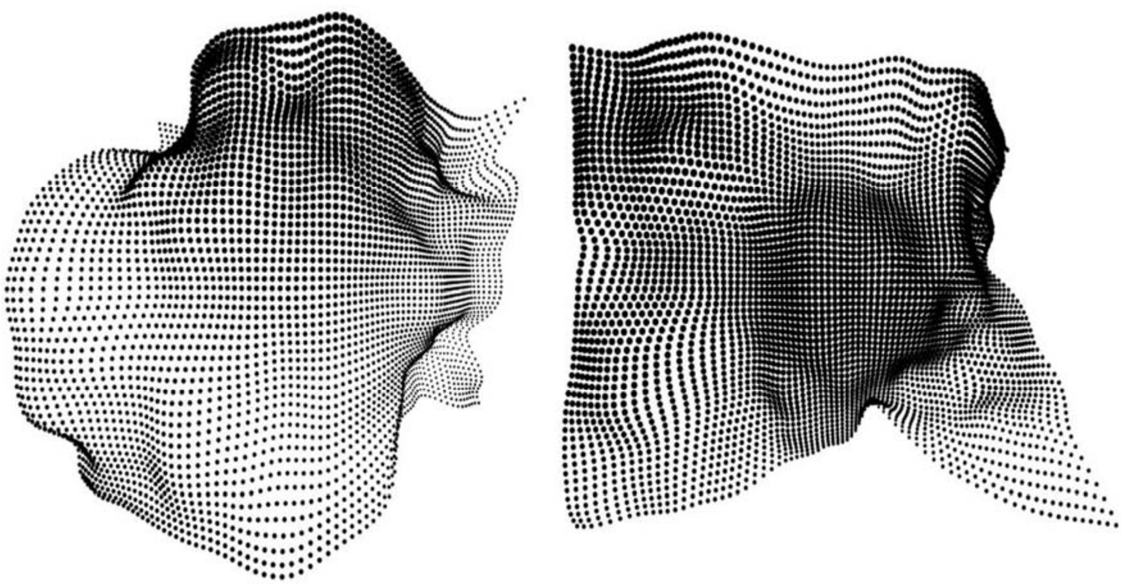


Figure 4.13: Wavy fields.

4.4 Complexity and Order

Computing extreme quantitative complexity in traditional design processes is always bounded in extent. However, combining an algorithm and a base image may be a strategy that restrains the algorithm and creates an order within complexity. Images are represented by a grid of pixels which are the smallest elements (Figure 4.14).

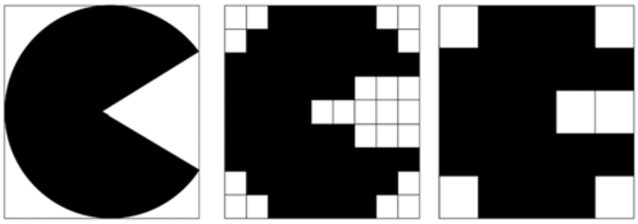


Figure 4.14: Pixelation of an image.

Reproducing images can be done by the data reducing each pixel to its colour value and changing design parameters such as rotation, width, height and area. Such coding can be written as:

```
for (int gridX = 0; gridX < img.width; gridX++) {
for (int gridY = 0; gridY < img.height; gridY++) {
float tileWidth = width / (float)img.width;
float tileHeight = height / (float)img.height;
float posX = tileWidth*gridX;
float posY = tileHeight*gridY;
color c = img.pixels[gridY*img.width+gridX];
int greyscale =round(red(c)*0.222+green(c)*0.707
+blue(c)*0.071);
float w1 = map(greyscale, 0,255, 15,0.1);
stroke(0);
line(posX, posY, posX+5, posY+5);
break;(…)}}
```

Even though grids are diagonals with only two possible directions, they might make complex structures. Overlapping creates new forms, connections and intersections. Individual forms abandon their strict arrangement in the dynamic grid and submit to random configurations. Sequentially, the pixels of an image are analyzed and transformed into other graphic elements. Linearly lined up pixels are an array and the pixel index data is taken from the grid position (gridX, girdY). Calculating the value of red, green and blue may display and identify different parameters to control the redrawn image (Figure 4.15). The way of thinking of human mind detects to find restrictions in complex images, however computer redraws boundaries and generates flowing alterations.

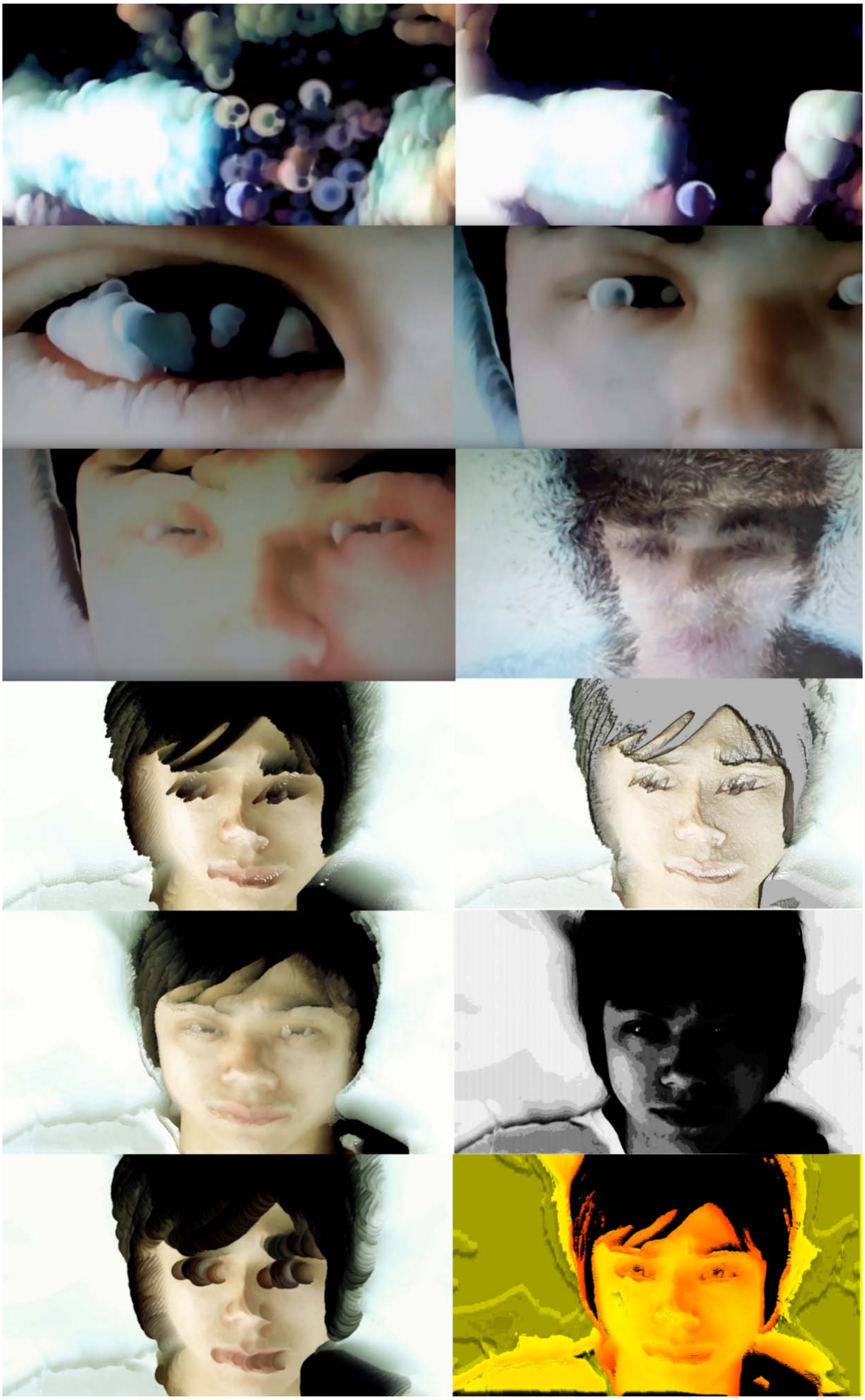


Figure 4.15: Blurryzooms, stills of the animation, personal project (Url-31).

4.5 Emergence

Emergent behaviour describes a system that depends on the relationships with one another, not only on their individual parts. Complex systems have individually simple elements, yet the behaviour of the system which emerges complex patterns is difficult to predict. It has to be controlled and managed by comprehension of all the parts and their relationships. Algorithmically, in order to get close to representing that wholeness, agents and a stored a list of particles in an ArrayList is needed for managing collections of individual elements. For simulation of animal behaviour, flocking as a flow, agents in that list have to be implemented some rules as like concepts such as steering a force formula, an implementation area of that force, alignment, avoidance and moving towards the neighbour (Figure 4.16).

```
class Flock {
ArrayList<Boid> boids;
Flock() {boids = new ArrayList<Boid>();}
void run() {for (Boid b : boids) {
b.run(boids);}}
(…)
void flock(ArrayList boids) {
PVector sep = separate(boids);
PVector ali = align(boids);
PVector coh = cohesion(boids);
sep.mult(1.5);
ali.mult(1.0);
coh.mult(1.0);
applyForce(sep);
applyForce(ali);
applyForce(coh);} (Url-32)
```

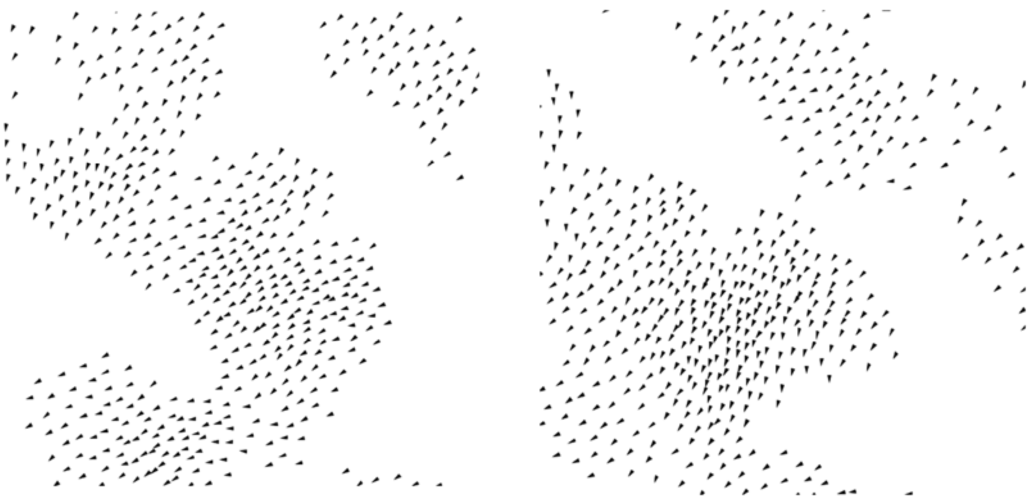


Figure 4.16: Simple flock behaviour.

If separation weight, cohesion weight, alignment weight and reproducing or reduction based on density and lifespan is changed over time, flows in still images may be more visible (Figure 4.17).

```
boolean isReduction() {
return (lifespan < 0.0);}
boolean isReproduction () {
return (age > 5 && density < 3 && density > 1);}
boolean isCrowded(){
return (density > 25);”}
```

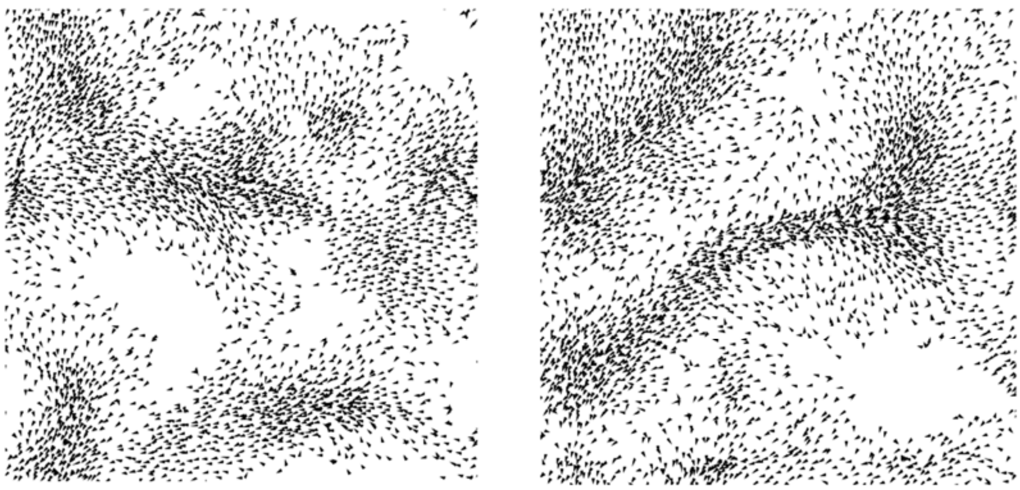


Figure 4.17: Flock change based on density and lifespan.

Applying drawing agents to vector fields and treating the values from noise as acceleration results in behaviours similar to fluids such as laminar flow, transition to turbulence or fully developed turbulence. The agents encapsulated in a class randomly dispersed throughout the display with the step size is varied slightly. Calculated angle using the agent’s current position can be influenced by the variables of scale and strength of the noise (Figure 4.18).

```
class Agent {
PVector pos;
float angle;
void update() {
pos.x += cos(angle);
pos.y += sin(angle);
float xx = map(pos.x, 0, width, -1, 1);
float yy = map(pos.y, 0, height, -1, 1);
PVector v = new PVector(xx, yy);
angle += map( noise(v.x, v.y), 0, 1, -1, 1);}}
ArrayList<Agent> agents = new ArrayList<Agent>(); (Url-
28)
```

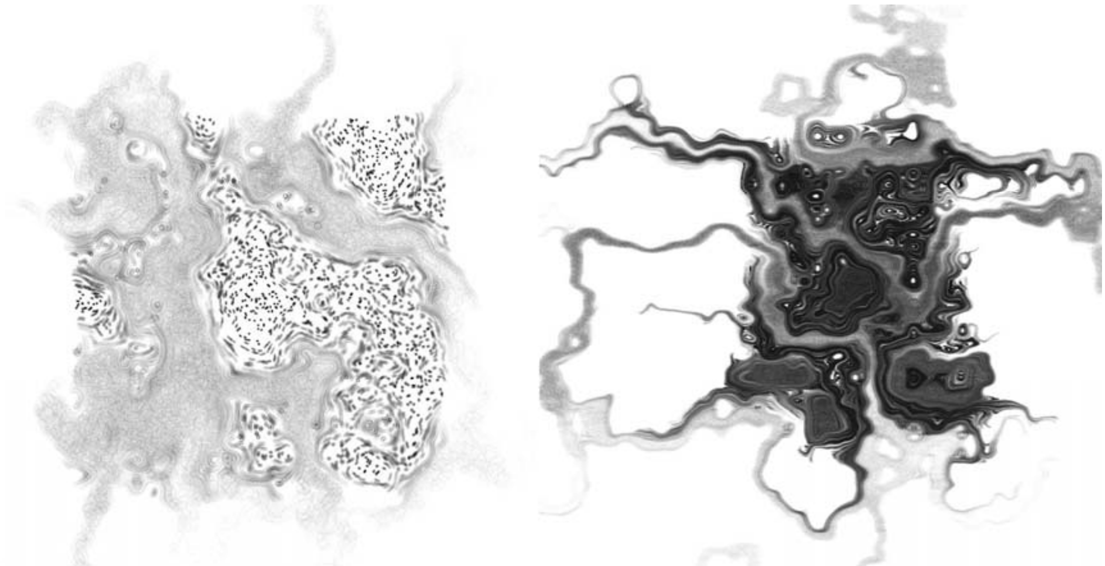


Figure 4.18: Agent-based turbulence generation.

Interactions between virtual entities which are staged by simulations represent the concept of emergence bluntly. Deciphering the probabilities of emergences can be made conveniently. Computer fluid dynamics has an appropriate content in the design optimization due to its ability to simulate flexible fluid flow and thermal changes, allowing data modification. Fluid dynamics simulations can be acquired both in mesh and analysis. Today’s engineering sciences use to simulate natural phenomena or mechanical studies by using the three-dimensional simulation tools.

In various situations using software, observing fluid behaviour and forms in real mania with the simulation's complex and dynamic curvilinearities of the forms produced to test a new design language formation can be made.

Diversified data such as the density of the liquid, the initial state (free flow or flow with pressure), the volume of the liquid or the way it moves, obstacles are changeable and comparable in simulation software. Computer simulations visualize fluid behaviours that are difficult to observe in real time. In the same unit of time, with the following experiments on computational fluid dynamics software which produces a non-mechanical motion understanding in the computer environment, the design process was tried by putting the flow metaphor into behavioural bases.

The important point in the flow of liquids is that the air in which the liquids flow is another fluid having surface tension. Obviously, all the fluids have a contractile force on the surface. The low surface tension in a path of liquid with the high surface tension affects the motion and shape of the fluid. If the fluid has a higher surface tension than the current space it flows, the force causes an effect that fluid wants to flow from the area of lower surface tension to the area of higher surface tension. At different velocities and free or gravity flows, that motion has experimented (Figure. 4.19,4.20).

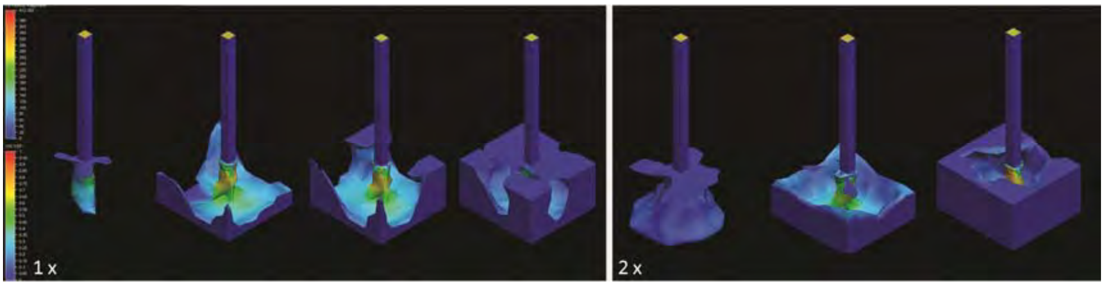


Figure 4.19: Gravity flows at different velocities.

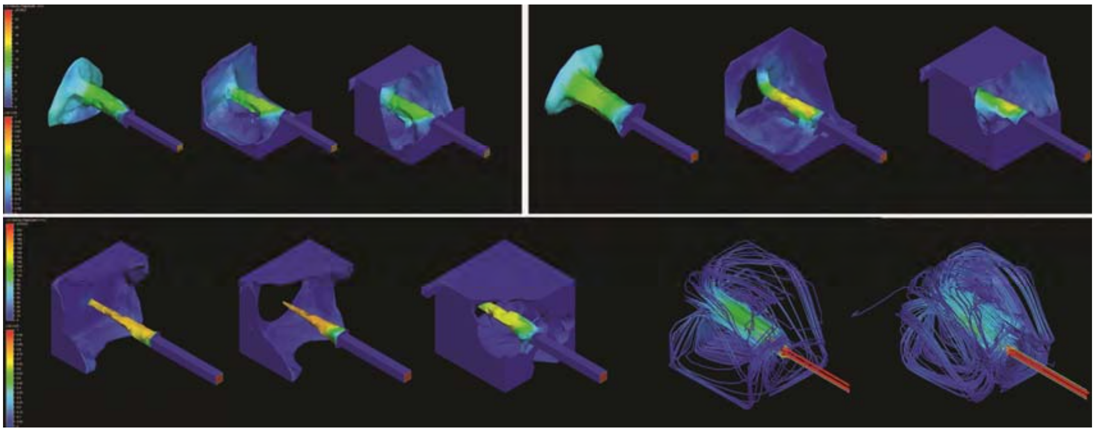


Figure 4.20: Flows at different velocities.

In order to visualize how fluids behave and interact with each other or their surrounding environment, the experiments over the space-filling qualities and the dynamic aspects of the fluids have been made (Figure 4.21). The steady flow of a fluid become faster in the narrower section and that space difference develops a transition from laminar to a turbulent flow having a high fluid flow rate (Figure 4.22).

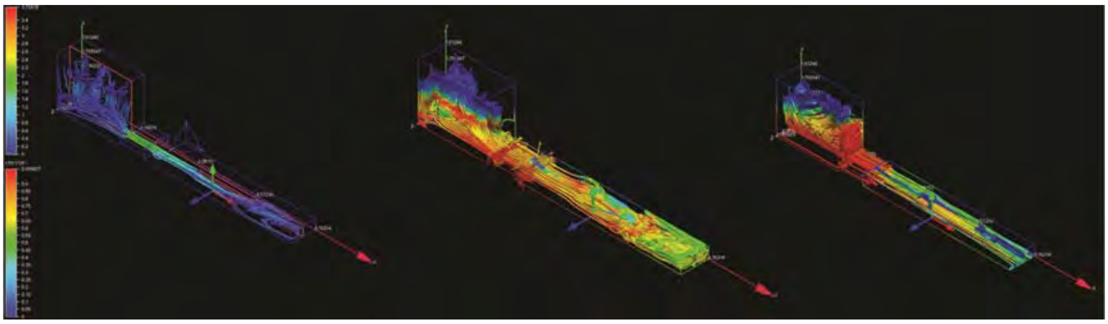


Figure 4.21: Streamlines of particles flowing across a narrow section.

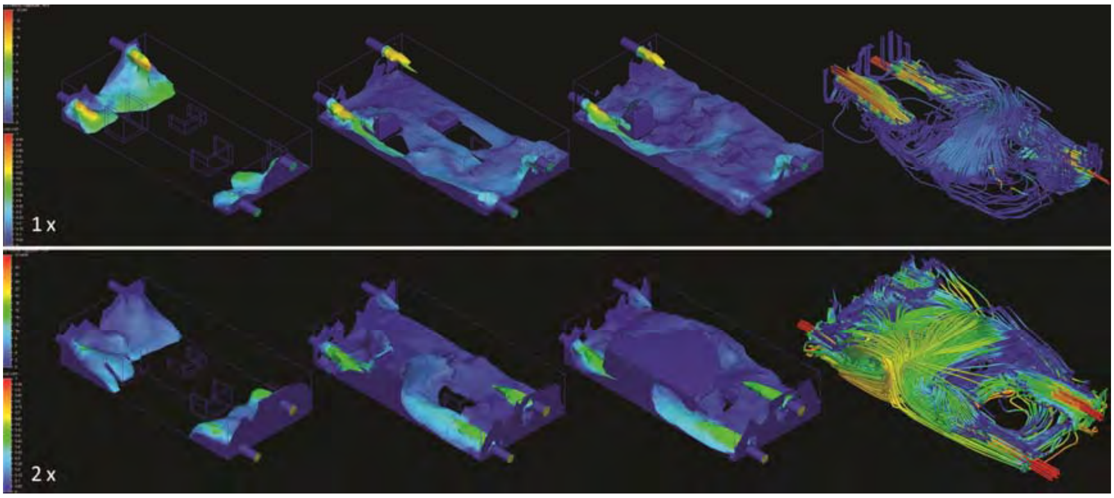


Figure 4.22: Flow encounters at different velocities.

The motion information of a particle over a time period captures the velocity of the same particle. Thus, particle advection fields give the information of where the particle moves in the next frame (Figure 4.23).

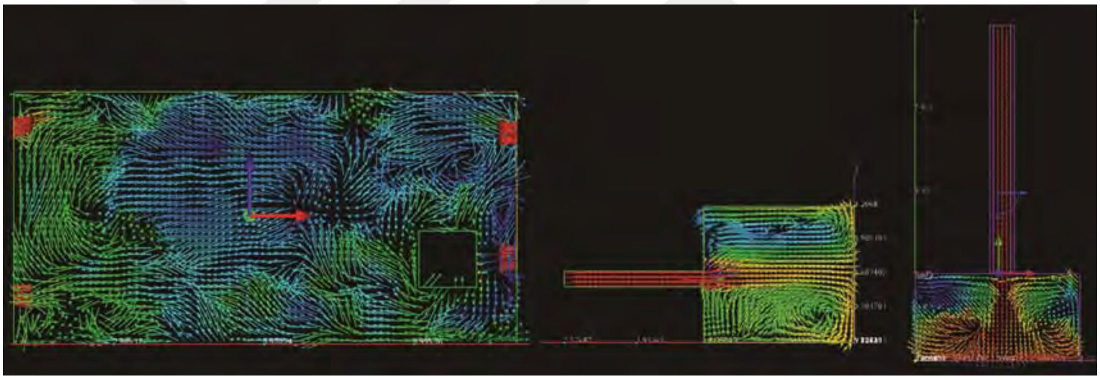


Figure 4.23: Particle advection of flows.

5. CONCLUSION

This study aims to contribute to design thinkings by interpreting flows as both a design object and a concept contributing to creativity. Conceptualization of flow via focusing on qualitative features and possibilities may break down the threshold barrier between virtual and actual. In this context, representations by means of algorithms are used as abstractions of flows.

Design processes are based upon numerous instinctive knowing such as interpretation, intuition etc. and do not take place in a wholly fixed or structured world. In algorithmic design, mathematics involving design process can create a multitude of possibilities, but the perfection of mathematical description of the process of describing the reality can bring the designs to the expected and previously observed situations. Within generativeness of algorithms, design process retains the capacity to surprise. In literal means, digitalization is to reduce the processes and is more about process, not the outcome. Unlike the manual world of design, explorations on concepts, processes or terms are not entirely conceivable or predictable. If design is about virtuality and not actuality, indefinite and uncertain conception in design processes should lead to the creation of new thinkings.

The logic of algorithms let the designer explore the potentials of emergences and the articulation of the ideas. In a way, algorithmic logic feeds the exploring design possibilities. Traditional design or computerization of design precludes breaking down the borders between the designer and the computer that keeps the ideas in a "black box". In short, the process's itself may be a constraint to the designer's imagination. In the actualization process of virtual, differentiation properties of algorithm create genuine produces each time. In the same manner, the concept of flow related to creativity and objectively of design can allow dialogue with other disciplines in the context of design narrative, thinking, visualization and perception. To be or become other and extending towards unexpected configurative transformations represented by computational media change the view of interpretation of designers.

Within this framework, this study explores the related notions of flow in nature, science, thinkings and art. In chapter 4, under the concepts of flow, algorithmic or simulated experiments have been made while the productivity of the concepts has been diversified with the adaptable structure of the computation. The virtual forms explored in this thesis are to liberate idealized approaches to the field of representation by adding new functionalities to the codes. Observable forms and field-based renderings of flows may be applicable to constructible forms by generating a new realm All the topics being tackled in the query are mentioned to redefine definitive definitions and terminate constraints. The state of formless condition of flows broaden concepts and reject boundaries. This way of thinking is not on distinguishing but on the previously unnamed hybridizations. Design should be considered through approaches that can manipulate growth conditions of uncertainty, variability and incompleteness. In this context, novel perceptions and abstractions to be possessed will have the potential to widen the ideas of thoughts, imagination and design. When considering the "nature" of design which actualizes itself through representation, abstractions and metaphors in this thesis may have potentials to enrich emerging design ideas.

REFERENCES

Addington, M. (2007). Contingent behaviours (Eds.), In Lally, S. *Softspace: From a Representation of Form to a Simulation of Space.* London: Routledge.

Allen, S. (1999). *Points and Lines.* New York: Princeton Architectural Press.

Allen, S. (2000). *Practice: Architecture, Technique and Representation.* Amsterdam: G+B Arts International.

Beesley, P. (2014). *Diffusive Thermal Architecture: New Work From The Hylozoic Series*, (pp. 90-100.), AD, London.

Bohm, D. & Peat, F. D. (2007). *Science, Order, And Creativity.* London: Routledge.

Bohnacker, H. (2012). *Generative Design: Visualize, Program, and Create with Processing.* New York: Princeton Architectural Press.

Budak, Z., Basik, A., Alacam, S. (2017). Blurry Boundaries: Queries on Boundary Phenomenon by Using Doppler Effect, *Generative Arts Conference,* Politecnico di Milano University, Ravenna, Italy, December 13-15, 2017.

Cache, B. (1995). *Earth Moves: The Furnishing of Territories.* Cambridge, Massachusetts: The MIT Press.

Carpo, M. (2013). *The Digital Turn in Architecture 1992-2012.* West Sussex: Wiley.

Davidson, P. A. (2004). *Turbulence: An Introduction for Scientists and Engineers.* Oxford: Oxford University Press.

De Landa, M. (n.d). Deleuze and The Open-Ended Becoming of The World. Retrieved April 20, 2018, from <https://www.cddc.vt.edu/host/delanda/pages/becoming.htm>

Delalex, G. (2006). Go with the Flow: Architecture, Infrastructure and the Everyday Experience of Mobility. University of Art and Design Helsinki.

DeLanda, M. (2010). *Philosophy and Simulation: The Emergence of Synthetic Reason.* London: Continuum.

DeLanda, M.(2002). Philosophies of Design: the Case of Modelling Software. Architecture Boogazine: Authorship and Information, No 1, Madrid: Actar Press. Retrieved April 20, 2018, from <http://www.digitaldrawing.tcaup.umich.edu/Readings/De%20Landa_The%20Case%20of%20Modeling%20Software.pdf>

Deleuze, G. (1995). *Difference and Repetition.* Columbia University Press.

Deleuze, G. & Guattari, F. (1987). *A Thousand Plateaus: Capitalism and Schizophrenia*. London: The University of Minnesota Press.

Fernández-Galiano, L. (2000). *Fire and Memory: On Architecture and Energy*. Cambridge, Massachusetts: The MIT Press.

Fishwick, P. (2006). *Aesthetic Computing*. Cambridge, Massachusetts: The MIT Press.

Flanagan, M. & Booth, A. (2011). *Re:Skin*. Cambridge, Massachusetts: The MIT Press.

Glendinning, P. (2012). *Math in Minutes*. New York: Quercus.

Gombrich, E. (1987)*The Image and the Eye: Further Studies in the Psychology of Pictorial Representation*, Oxford: Phaidon.

Grosz, E. (2001). *Architecture from the Outside: Essays on Virtual and Real Space*. Cambridge, Massachusetts: The MIT Press.

Hesel, M. & Menges, A. (2006). *Morpho-Ecologies*. London: AA Publications.

Hugo, V. (1834). *The Hunchback of Notre-Dame*. Harvard University digitalized version.

Ito, T. (1999). *Blurring Architecture 1971-2005 - Rethinking the Relationship Between Architecture and the Media*. Milano: Charta

Klee, P. (1925). *Pedagogical Sketchbook*.London: Lund Humphries.

Klee, P. (1956). *Notebooks: The Thinking Eye*. New York: Frederick A. Praeger, Inc.

Lally, S. (2014). The Air from Other Planets: A Brief History of Architecture to Come. Baden: Lars Müller Publishers.

Lavender, G. (2017). Math in Minutes. New York: Quercus.

Leski, K. (2016). The Storm of Creativity. Cambridge, Massachusetts: The MIT Press.

Luding, S. (2008). Introductıon to Discrete Element Methods. Retrieved April 20, 2018, from <https://www2.msm.ctw.utwente.nl/sluding/PAPERS/Alert_Luding2008.pdf>

Maeda, J. (2001). Design by Numbers. Cambridge, Massachusetts: The MIT Press.

Pallasmaa, J. (2014). Unconscious perception and creative thought (Eds.), In Borch, C. Architectural Atmospheres. Basel: Birkhäuser.

Pearson, M. (2011). Generative Art: A Practical Guide Using Processing.New York: Manning Publications Co.

Picon, A. (2010). *Digital Culture in Architecture*. Basel: Birkhäuser.

Reas, C. (2010). *Form+Code in Design, Art, and Architecture*. New York: Princeton Architectural Press.

Rheinberger, H. (2010). *An Epistemology of the Concrete: Twentieth-Century Histories of Life*. London: Duke University Press.

Stalder, F. (2006). *Manuel Castells: The Theory of the Network Society*.Cambridge, UK: Polity Press.

Terzidis, K. (2006) *Algorithmic Architecture*. Oxford: Architectural Press

Tierney, T. (2007). *Abstract Space: Beneath the Media Surface*. New York: Taylor & Francis.

Url-1<https://www.william-turner.org/Snowstorm.html>, date retrieved 30.04.2018.

Url-2 <https://unsplash.com/@nasa>, date retrieved 30.04.2018.

Url-3<https://www.flickr.com/photos/ironypoisoning/12220693513>, date retrieved 30.04.2018.

Url-4<http://www.northernlightscentre.ca/northernlights.html>, date retrieved 30.04.2018.

Url-5<http://www.richardbarnes.net/murmur-1/ >, date retrieved 30.04.2018.

Url-6<https://www.doc.ic.ac.uk/~nd/surprise_95/journal/vol4/ykl/report.html>, date retrieved 30.04.2018.

Url-7<https://www.cca.qc.ca/en/issues/4/origins-of-the-digital/1829/a-roof-can-be-anywhere>, date retrieved 30.04.2018.

Url-8<https://www.youtube.com/watch?v=GFgCHxrJAOA>, date retrieved 30.04.2018.

Url-9<http://gdemontfort.tumblr.com/post/1506161774/diagram-architecture-toyo-itos-sendai>, date retrieved 30.04.2018.

Url-10<https://www.youtube.com/watch?v=L8AvW5CSvys>, date retrieved 30.04.2018.

Url-11<https://www.youtube.com/watch?v=L8AvW5CSvys>, date retrieved 30.04.2018.

Url-12<http://www.victorianweb.org/painting/ruskin/drawings/58.html>, date retrieved 30.04.2018.

Url-13<https://www.gerhard-richter.com/en/art/paintings/#photo-paintings>, date retrieved 30.04.2018.

Url-14<https://stamen.com/work/cabspotting/>, date retrieved 30.04.2018.

Url-15<https://www.simscale.com/forum/t/les-flow-analysis-around-cylinder-simulation-project-by-ali-arafat/740/2>, date retrieved 30.04.2018.

Url-16<http://dada.compart-bremen.de/item/agent/15>, date retrieved 30.04.2018.

Url-17<http://enohenze.de/der-wirklichkeitsschaum/ >, date retrieved 30.04.2018.
Url-18<http://enohenze.de/ambush/ >, date retrieved 30.04.2018.

Url-19<http://www.kokkugia.com/swarm-urbanism>, date retrieved 30.04.2018.

Url-20<http://www.museeorsay.fr/en/events/exhibitions/archives/exhibitions-archives/browse/9/article/mouvements-de-lair-etienne-jules-marey-1830-1904-photographe-des-fluides4216.html?S=&tx_ttnews%5BbackPid%5D=252&cHash=59e29a534e&print=1&no_cache=1&>, date retrieved 30.04.2018.
Url-21<https://www.moma.org/collection/works/45796?artist_id=3067&locale=en&page=1&sov_referrer=artist>, date retrieved 30.04.2018.
Url-22<http://desmondhenry.com/gallery/>, date retrieved 30.04.2018.

Url-23<https://www.youtube.com/watch?v=c-AHtUsO6Wc>, date retrieved 30.04.2018.

Url-24<https://www.teamlab.art/e/bandaijima/>, date retrieved 30.04.2018.

Url-25<http://olafureliasson.net/archive/artwork/WEK101824/beauty>, date retrieved 30.04.2018.

Url-26<http://www.philipperahm.com/data/projects/digestiblegulfstream/index.

html>, date retrieved 30.04.2018.

Url-27<https://github.com/shiffman/The-Nature-of-Code-Examples/tree/master/chp06_agents/NOC_6_06_PathFollowing>, date retrieved 30.04.2018.

Url-28<https://generateme.wordpress.com/>, date retrieved 30.04.2018.

Url-29<http://www.generative-gestaltung.de/1/M_2_5_01>, date retrieved 30.04.2018.

Url-30<https://github.com/shiffman/The-Nature-of-Code-Examples/tree/master/chp03_oscillation/NOC_3_06_simple_harmonic_motion/>, date retrieved 30.04.2018.

Url-31<http://www.zey.works/blurryzooms/>, date retrieved 30.04.2018.

Url-32<https://github.com/shiffman/The-Nature-of-Code-Examples/tree/master/chp06_agents/NOC_6_09_Flocking>, date retrieved 30.04.2018.

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- **Budak, Z., Gamsız, Ö.** (2017). "Akışkanların Modellenmesi (Modeling of Fluids)" , Middle East Technical University, Ankara, Turkey, June 14-15, 2017. (Poster Presentation)