Understanding the empirical process of animating to open up the field of stop motion analog simulation

Cyril Lepot
Institut ACTE - UR7539, France

Abstract

As a stop motion specialist I tend to think it less as a relic than as a persisting medium, especially since this kind of production is still vivid in the film industry but also because I think some practices, or ways to use the medium are still not cleared because they are only considered as effects, not as an entire way of making a whole film.

On the one hand it's not only about theorizing but opening up new fields and developments based on what has already been done, sometimes unconsciously by artists. On the other hand we also feel the urge to free ourselves from discourses and practical tips given by the animators themselves. Most of the time stop motion animators are engaged in an empirical process leading them to a no less empirical knowledge. I myself discussed it with Patar and Aubier from the Beast animation fame and they don't have much clue they are promptly and punctually disguising, transfiguring and thus transmuting matter, they only think in terms of material and technic limitations and how hint (or elaborated tricks) can help them solving it when trying to convey something on screen.

That's why we would like to engage ourselves into a physics-based analysis that would be a real asset to assert, didactically, what cause leads to what effects when animated one way or another, for example, exactly what kind of material can be used and what kind of manipulation or substitution leads to that effect of matter.

Keywords: Stop motion, Analog, Simulation, Virtual, Transmutation.

Overview of the state of stop motion development since the beginning of the new millennium.

Here we chose to focus on feature films (clocking at least at 50-60 minutes) and omit on purpose TV series, shorts or mixed media and special effect movies involving stop motion for it is the dynamicity of that format that is at stake and really makes it possible to talk about stop motion's breakthrough in the world's cinema industry. It will help us underline if medium developments come with its recognition. Another preambular provision has to be made on the timescale subject since the first full stop motion feature film date back to Irene and Ladislas Starevich's The Tale of the Fox (1937) and Jiří Trnka's The Czech Year (1947). Admittedly stop motion films, because of the time-consuming process, amount of material and craftsmanship involved was developed mainly through shorts and TV series for light and humorous purposes but also remained for decades as an old-fashioned, yet charming, visual effect because of its use by animators O'Brien and Harryhausen for live action films. Most Starevich, Trnka then Pojar and Barta works were shorts and Švankmajer never did stop motion only movie, far from it. Pioneering, both aforementioned feature films were poorly distributed, even in Europe. Added to that is the fact all these directors came from a secluded Eastern Europe, even if Starevich mainly lived in France and Czech puppetry was known worldwide. Thus, sadly it comes with no surprise stop motion would take a long time to rise, eclipsed by western live action and cartoon. Bus as much as ill-fated Emile Reynaud's work can be considered a technical false start both for live action and cartoon, we can consider a series of false starts with stop motion, in terms of recognition and development, that lasted until the nineties, coinciding with the cartoon's crisis and the rise of CGI animation. We will see that one medium may need many aftershocks with an increase of frequency to finally take off and find its cruising speed.

Aardman's *Chicken Run* (2000) critical and commercial impact has produced long time and definitive game changing shockwaves amongst the animation feature film – showing at the same time that traditional animation was not outdated in the then uprising era of computer's animation since Pixar/Disney's *Toy Story* (1995) and its sequel (1999) success, but also that stop motion, despite *The Nightmare before Christmas* (1993) already cult status, was still an underused medium longing for developments at that time. Instantly, one can be inclined to think about correlation or even causality and wonder if computer's animation 3D appeal led to acquire or at least reinforce strongly the taste for plastic volumes, surfaces and lightings already found in Henry Selick's 1993 first feature film effort. But for now, let's consider the recent historicity of stop motion feature which is not to be seen as a progressive or linear rising phenomenon and is anything but a long and quiet river.

One wouldn't theorize a new dawn of stop motion in theaters but more likely describe it intermittently because of the time-consuming process staggering the releases or by surge thanks to new studio appearing. For example, it took another 5 years to Aardman to release *Wallace & Gromit: The Curse of the Were-Rabbit* (2005) but the stop motion phenomenon took a new pace at the twilight of the years 2000 when Selick joined the newborn Laika studio producing consecutively *Coraline* (2009), *ParaNorman* (2012), *The Boxtrolls* (2014), *Kubo and the Two Strings* (2016) and *Missing Link* (2019). Economists would say the competition with Aardman, releasing on its side *The Pirates! Band of Misfits* (2012), *Shaun the Sheep*

Movie (2015), *Early Man* (2018) and *A Shaun the Sheep Movie: Farmageddon* (2019) led to a virtuous dynamic or to a mutually beneficial workout. However, it certainly is both the fact the studio and its technics are well established and helped by increasing digital technologies reducing the workload on the one hand, added to the fact renowned live-action movie-makers are also propelling the niche market, giving an arty auteur cinema and adult edgy legitimacy on the other hand.

Like Richard Linklater with the rotoscoping technic on *Waking Life* (2001) and *A scanner darkly* (2006) it was only logical then, that Tim Burton, who produced *The Nightmare before Christmas* (1993) and Selick's (not 100% animation) *James and the Giant Peach* (1996), initiate the production of feature film at the newly founded Laika studio with *Corpse Bride* (2005), then *Frankenweenie* (2012) both shot at 3 Mills Studios.

In fact, we will see that a newfound interest from famous directors for a one shot stop motion essay arrives at a time the studio couple formed by Aardman and Laika are losing momentum and slowing down the production pace for obvious lack of profitability. Indeed, lately Aardman is playing a risk-free status quo by creating two sequels instead of original works: *Shaun the Sheep Movie: Farmageddon* (2019) and *Chicken Run: Dawn of the Nugget* (2023). The studio even surrenders to streaming platforms with this upcoming release being exclusive to Netflix online. Talking about franchise reboot it's not surprising that, at the same period, the Finnish best-seller comic-book *The Moomins* (1945-1993) was to remind how much its legacy of adaptations contributed to popularize stop motion back then by compiling and restoring some episodes of the 1977-1982 TV series so as to make feature films: *Moomin and Midsummer Madness* (2008) followed soon by *Moomins and the Comet Chase* (2010), *Moomins and the Winter Wonderland* (2017) and *The Exploits of Moominpappa* (2021). Let's not forget that the original TV series was only broadcasted in a few countries so it looks brand new to most of the people in the world.

Also because it was very successful in its country in the seventies, a stop motion movie – the last from Norwegian innovator puppet master Ivo Caprino called *The Pinchcliffe Grand Prix* (1975) – inspired CGI animation director Rasmus A. Sivertsen, to produce a trilogy based on Kjell Aukrust's original characters Solan & Ludvig: *Solan and Ludvig: Christmas in Pinchcliffe* (2013), *Louis and Luca – The Big Cheese Race* (2015) and *Louis & Luca - Mission to the Moon* (2018) as long as *In the Forest of Huckybucky* (2016). The director is nowadays mainly back to CGI animation and even tried mixed media on *Three Robbers and a Lion* (2022), incorporating stop motion animated characters into an entirely digitally generated set.

The interest for stop motion really took off in the impressive 2009 burst with *Mary and Max*, *Fantastic Mr. Fox*, *Coraline*, *A Town Called Panic*, *$9.99* and *Toys in the Attic*, something that, right on, led me choose this medium as the central subject to my thesis started in 2010, now available on internet[1]. But it's only with the very recent Wes Anderson's *Isle of Dogs* (2018) that the medium enters the realm of recognized adult mainstream cinema through its creator's fame and press promotion. Indeed the dark tone and understated design adds to the gravity of dialogues and situations, something that could be already found in its previous stop motion film, *Fantastic Mr. Fox* (2009), which was not as beneficial moneywise, as Anderson's new essay with the medium, proving the risk to address the adult audience can pay off.

After 2009, the beginning of the 2020 decade could be seen as the second wave of stop motion modern breakthrough and definitive return in the spotlight, this time because of famous veterans with *Guillermo Del Toro's Pinocchio* (2022) expected economic success and Phil Tippett's *Mad God* (2021) (a renowned special effect animator's from Lucas' Industrial Light & Magic legendary company) or newcomer autodidact Takahide Hori's *Junk Head* (2021) critical success, especially with scie-fi and fantasy movie fans. Unexpectedly, both the latter directors are in fact multitask artists nearly creating entirely the film on every aspect and on their own, something that deeply question, in the youtuber's era, the traditional economical model and the loss of profitability in movie making, which was already at stake with Marvel or DC superhero movies much based on CGI but also with TV series then and streaming platforms nowadays. Let's not forget the latest Selick movie, *Wendell and Wild* (2022) was released on Netflix only and *Chicken Run*'s sequel will follow the same path.

Here ends our heavy but necessary introduction based on an historical and cultural study methodology to open up a didactic theorization of what we think constitutes the most specific content delivered by the stop motion technique, which is still, odd enough, underdeveloped regardless of its boom since the new millennium.

Thinking stop motion as an analog simulation.

I think some practices, or ways to use the medium are still not cleared because they are only considered as effects within stop motion movies, not as an entire way of making a whole film. Moreover, it is not only relatively to other art theories that it is possible to rethink stop motion but more practically relatively to 3D animation, in the sense that it is possible to compare algorithmic simulation performances to stop motion's analog simulation that led me thinking the animator as some kind of empirical agent.

As already quickly addressed there is a strong link between CGI animation and stop motion, not only because of the renewed taste for volume, texture and three dimensional space but more precisely because both techniques are simulations, just as "AI" video compositing and animating is also now. Human is not evicted from the process, from CGI to AI, his implication

is distanced a step further has algorithms allows to determinate not a tool in traditional terms but refine auto decisional processes and implement them higher (or sooner) in the causality chain leading to the final product. The artist agency stands; he is only stepping or leaning back in a shift that is more quantitative that qualitative between CGI and AI imagery production. Not only a command is always needed but subordinate commands derive from algorithms and learning process implemented by human and picking up raw materials or models into a given database. The latter is human based at the end of the day, only the vastness from which the AI draw the information from and the quantity of restless decision makes it alienating or "inhuman". So, the less the medium is relying on digital tools handled by humans, the more intern elements of the whole simulation are becoming simulation themselves because any parameter can be ruled by the AI.

This result in a new degree of simulation when the difference between stop motion's analog simulation and the one produced through CGI animation can be considered a qualitative leap without having to discriminate which solution is the more artistic. We will see that analog simulation is not about mimicking as it is the case with digital simulation trying to approximate a design or physical phenomenon by using an algorithm that can be used to produce a numerical modelling. Instead it tries to convene empirically on the screen some of the indices that could make the spectator feel the presence of the object and its temporalization. It's a simulation based on effects which are, as such, far from being approximations. These effects calls for the credulity of the audience and its amusement, knowing well enough he is facing a trick but enjoying it nonetheless.

In this analysis, on the one hand it's not only about theorizing but opening up new fields and developments based on what has already been done, sometimes unconsciously by artists. On the other hand we also feel the urge to free ourselves from discourses and practical tips given by the animators themselves. Most of the time stop motion animators are engaged in an empirical process leading them to a no less empirical knowledge. I myself discussed it with Patar and Aubier from the Beast animation fame and they don't have much clue they are promptly and punctually disguising, transfiguring and thus transmuting matter, they only think in terms of material and technic limitations and how hint (or elaborated tricks) can help them solving it when trying to convey something on screen.

How to describe effects of matter in stop motion?

The advent of educational video streaming has been accompanied by so called "viral" oddly satisfying videos on popular YouTube channels like The Slow Mo Guys or Experimentboy. These videos are akin modern attractions but are also working like playful learning about physical phenomenon. Most of them are common display such as compression, stretching or explosion of materials frequently enhanced by high speed camera recording but we can also witness astonishing and rarely seen phenomenon in the everyday life. Such videos presents ferromagnetic fluids, drop of water coalescence cascade, walking droplet above cavities, bursting balloon, plasma ball, cutting laser, Lichtenberg figures, laminar flow, acoustic or quantic levitation, non-Newtonian fluids like oobleck, slime or silly putty but also granular flow influenced by acoustic waves. On the institutional side, we have French scientists interested in scientific outreach presenting astonishing phenomenon, among them Duran, Guyon, Bobroff or Lehoucq. For example, Bobroff shows some of the rare quantic effects that can be witnessed on our macroscopic scale when Lehoucq is testing how plausible science-fiction objects or technologies (like a spaceship) can be, but also what's the far-reaching impact of technics on human life.

For its part, stop motion can be seen as a medium where the credibility of matter (like fluid for example) behaviour is at stake for animators are trying to convene physical qualities on the screen basing their work on matters that do not hold these properties at first. We can comment their credibility but it's even more relevant to underline the specific process used to simulate analogically these behaviours frame by frame. This specific trompe l'oeil, for it only exists through the frame by frame emulation of animation, brings forth physical qualities of objects that reinforce the narrative in the sense that matter becomes also a fictional product. It's not much a new reality as such that is created since it's more about creating effects of matter referring accurately to the largest panel of material qualities, as we encounter them in the everyday life.

Common physics shows that various laminar flow[2] are obtained by reducing turbulence in the flux, for example by funneling through tubes the individual streamlines of the current. It gives a glassy aspect to water so that it is possible to create fountains where the water flow is so stable that, seen from afar, the flux looks like a sculpted pipe: no movement can be distinguished but it still is a liquid and not a solid. This suspension effect happening through actual movement can also be highlighted with ferromagnetic fluids because of electromagnetic currents. They seem to slip and shift easily from one shape to another. Apart from versatility the spike form it takes informs paradoxically a very solid character so that it instantly reminds the (computer generated) T-1000 properties in Terminator 2: judgment day (1991). On the contrary, very instable fluids can shape very still figures with singular dynamics even if it is for a very short time. Slow motion techniques allow playing on time scales and help to reveal such characters. A 10 000 frames per second recording screened in slow motion makes visible the fact that a water droplet falling into water split into two parts, one penetrating the surface, the other one bouncing on the surface many times, its size dwindling until it disappears into water. Dynamic effects of suspension can be found through the classic levitation experiences for it is possible to unstably hold a water droplet inside a dynamic system of acoustic

stationary waves whereas quantum levitation uses superconducting material reacting to a magnet's electromagnetic waves.

Here, we can foresee that it is indeed the state and behaviour of the now called complex matter that will interests us for the actual physical model can help us describe the specific dynamic of profilmic materials. These can be assimilated to the complex fluid category because their properties are intermediate, in the sense that sometimes they look solid, sometimes fluid and other times both. We will argue that such material behaviour are not provoked as it is the case in Newtonian material (under the influence of pressure or temperature) or in non Newtonian fluids (because of the strain impacting the microscopic structure and so the qualities of the material). In fact, they shall relate to a filmic structure and to a specific mode of space-time recomposing calling for the animator's inventiveness to transform object into others, especially in terms of materiality enhancement. Interframe manipulations or substitutions implies another kind of substitution, this time more generally on the material level and thanks to the contraction and dilatation of time, or the play with timescale as said before. Enhancement or sublimating is to be thought as something that is not a state change, like sublimation on a physico-chemical way of speaking but nevertheless not as speculating as the alchemical sense of transformation or abstract transmutation which is related to a spiritual and vitalist elevation of matter.

Slow motion alike time-lapse are based on the relativity of timescale for the first process consist in compressing the interval between two camera shots (a fine shredding of time is then stretched when screened) when the second one is based on a very long take (or shots repeated distantly in time) but projected fast-forward. Time lapse is already giving us amazing views when delivering the singularity of fluid spreading, whereas on an everyday basis we are used to our perception only giving us a synthesis or a kind of rough and blurry "summary" of phenomenon which are developing through long period of time like a plant growth or insects' moulting. It is not only an upgrade from our misleading perception since we are offered to finally witness how things are evolving and more generally the "intimate life" of matter itself or the unveiling of the once hidden dynamic of phenomenon. For example, the complex evolution of some matter deforming, fastly flowing or exploding is now revealed to the point we are rediscovering body's' gesture, its muscular tensions or we come to learn how energy is dissipated when a water bubble is bursting. In stop motion animation we do not witness actual flow as in time-lapse accelerated viewing, but simulations through the emulating frame by frame process. More precisely, the animator induces an artificial timescale through which the event is inscribed not so much to convey a brand new effect of time perception but to normalize or to give a natural appearance to pseudo-phenomenon that never happened in front of the camera. Indeed, the animator works for maximum likelihood image reconstruction relatively to apparent matter qualities in the sense it makes the spectator forgetful of the original quality of the matter really used. The plausibility of the object appearing on screen is rooted in the restitution of properties, thus simulated: the objects' constitutive matter is in fact empirically found in the animation process. This kind of "inverted" cinema that is frame by frame conceals its own logic on two levels: the way it simulates an event, something happening in time on screen and the way it simulates material qualities. It is in effect because the handling, the altering and the substituting participate, each with different degrees, to a general manipulation or trick that the spectator attests to the quality of a wide range of material or substances. The animator distort and thus disguise the materials factually used, passing them off as other materials.

The slow motion device, for its part, consists in decomposing movement thanks to a high speed camera (the recording goes up to 30 000 frames per second nowadays[3] even if laboratory cameras can record up to 4 million frames a second). Screening these images at a low speed rate reveals the complex forms some materials are taking during fast flowing, bursting etc. As with time-lapse we find out new realities and ways of visually conceiving texture, gesture, fluidity, and more generally physics or dynamics, like tension surface effects. The strangeness and the unintuitive variations delivered by time-lapse and slow motion are respectively depending on the slow pace and on the brevity of the phenomenon recorded: either it is usually unseen in the common experience because of its speed, either it is ungraspable because of its slowness. The astonishment when discovering these images results from a relative lack of knowledge whereas stop motion or computer generated imagery (CGI) producer are basing their description of the world on our common knowledge, for instance the fluidity notion we are used to. A slow motion visualization of fire appear as an oddity for it defies our intuitive knowledge based on our perception, to the point it looks false or "overrated" somehow so that it's like a bad CGI rendering. In fact, algorithms are used to tentatively create numerical modelling most approximate to the real phenomenon (material behaviour) and thus differ from the day-by-day average or limited perception. To a certain point, frame by frame animated flames with the stop motion technique seems more accurate and closer to what we are used to see[4] even if it's an effect obtained through a strange backdoor way and based on what is, at first, strictly not a versatile or fluid substance. In the same manner, the natural depth of field is more akin to our natural view than stereoscopic 3D.

Paradoxically, the movie in search for high photorealism effect, to the exclusion of documentary, find itself trying to "justify" as a relevant effect the surreality of phenomenon represented at slow pace and very near to slow motion, just like various elements on screen highlight a series of regularly spaced depth level in stereoscopic 3D. In both cases, it's a scheme to normalize images we are not comfortable with by making it work as a special effect or a new attraction.

Indeed, human perception definitely confined itself to a certain degree of acquisition of movement for we have limited access to fast movement and our lifespan cannot testify very slow events spanning on decades or more. But we are also constrained by the fact visual perception is a 2D reconstruction based on space hints like light and texture gradient and also in terms of colours and information on the environment because we can only see through the “visible light” spectrum that do not span the whole electromagnetic spectrum.

Stop motion is closed to slow motion because each medium uses, although differently, shots spaced in time. When screened, the picture seems to produce a precarious temporality for it may freeze at any moment. But stop motion is also close to time-lapse for the specific time contraction or condensation made possible by the frame by frame emulation process. For this reason, it comes with no surprise that the uninformed layman mistakes stop motion for time-lapse or that this is one and a same technique. In fact, stop motion animation polarizes two a priori antagonist modalities from both slow motion and time-lapse techniques: the gap between shots and the abridged temporal structure, except the abstraction effect that follows and that is retrieved is more than an abstract or a summary. The process is a crucible where quantitative variations delivers a qualitative gain that can’t be reduced to both mechanisms. It is as if stop motion was about accelerating a flux of time when at the same time neither actual event nor phenomenon precisely taking time (to develop, spread, flourish or to bloom for example) is being recorded.

Slow motion or time-lapse can be considered unseen events because of human limit of perception, to which they are brought so that they now look relevant to the eye. A scale ratio is found according to the timescale we are evolving that is the field of understanding where we can grasp things. A larger spectrum or a wider range of details can thus be artificially reached by perception so that we can consider it as high resolution description of space and time. To measure such unobservable phenomenon is not without consequences: time is normalized but what happens materialize in the form of new kind of material stream which resembles, in stop motion, uncontrolled surface instabilities or handling mistakes from one shot to another and wrong camera set ups producing various discontinuous effects.

The regularity of shooting in time-lapse or slow motion is relative to the reproductive function of these techniques whereas event or change is provoked and only “happens” through the animation process. We can’t deny slow motion or time-lapse are still two recording process even if it changes the material appearance of things we think we use to know. The fast forward enhance the vectorial aspect of flux and highlights some among others when the slow pace underlines the material aspect of the flux. Stop motion’s event are timeless, only exist virtually and artificially, as simulations, so that this technique can help composing a material rendering mainly by playing with two parameters already evoked here. In stop motion films we are not surprised by matter “acting” strangely like in slow motion or time-lapse, although, we are astonished by its transfiguration. We are drawn into this game of effects of matter, or more precisely matter behaviour simulations, that have for effect we assimilate, nearly as trompe l’oeil, plastic for water, wool for smoke, etc. Sometimes in our everyday life we encounter brief dynamics of matter that already make us wondering, for example, the glassy feel of water flowing on hydrophobic surfaces like duck feather.

Any of the three techniques can illustrate the relative viscosity of fluids that can be mistaken with absolute fluidity depending on the timescale manipulation. However, the slow motion of a Newtonian fresh paint “dancing” while vibrating on a speaker diaphragm gives a viscous character to it while still laminarly and linearly flowing. The same experience with a non Newtonian material gives a way more viscous but also stranger character to it. The singular properties of Newtonian as much as non Newtonian materials are linked to shear forces that cause the fluid to react in terms of changes of state or phase while producing a series of sculptural suspension as much as turbulent forms. Stop motion can lead to way more astonishing and counter-intuitive dynamic effects than these slow motions for it becomes possible to substitute the role of shear forces and other material stresses with a specific type of manipulation happening “out of time”.

A model taken from physical sciences to describe the variable character of matter relatively to a specific kind of strain.

From here, we need to dig more precisely into rheology and fluid dynamics to be able to describe more precisely behaviours of matter[5]. Condensed-matter physics is the domain interested in the macroscopic properties of matter, distinguishing non generic phases (intermediate or transitional states) like fluid state (neither liquid or gaseous but still not solid, superfluidity, superconductivity) from generic phases: solid, liquid, plasma and gas. In fact, this domain instigate that movement should be thought in terms of behaviour of matter according to the intrinsic qualities of matter on the one hand and relatively to the strained applied on the other hand[6] more than in terms of position in space or any other modification in time. For that reason, we should distinguish kinetic from kinematic descriptions[7]. If electromagnetism takes part in the process of matter alteration and stability we also know that warmth corresponds to molecule agitation which amounts to a dynamic modification of matter’s internal structure for it implies weak atomic bonds. In all, a change within matter corresponds to a change of its qualities such as a liquid state or a more or less bullous or viscous aspect. Let’s note here that it doesn’t mean I will stick to the plasticity notion according to physics since it only refers to a material resisting to strain without breaking.

In fact, I ought to show that some stop motion contents are not to be explained by what usually causes

the specific behaviours of one matter or another but are akin to its effects like viscosity. Indeed, instead of debating the ontological definition of matter we have to consider how its properties emerge from interactions at different levels or scales and can't be reduced to its simplest components. Moreover, this intimate structure reveals the preponderance of movement and energy within matter but also the "sensitivity" to external conditions (gravitations, thermodynamic laws, etc.). In all, the underlying and invisible dynamic happening on the microscopic but also on different timescales adds to the limitations related to our limited perception already conditioning our everyday experience (colours, movement, scent, tactile feel). It leads us to see how science can help us describe astonishing visual and material phenomenon.

In the variety of motion picture mediums, when the experiment on transformation or even transmutation of matter is less metaphorical, we are logically more inclined to consider how it relates to actual models used by physics to describe the behaviour of matter. For that reason I think there is no need to speculate on the vitality or abstract energy, substance or fluid that is underlined by these behaviours. First, no real forces are at stake in stop motion, they are absolutely fake in the sense the simulation is deducted and not induced by any kind of "engine" or process based on causality. Secondly, witnessing an imaginary world do not implies automatically we have to fantasize what could explain the exotic matter. Instead, we can describe to what extent it refers to actual known and well described phenomenon, but also underline how it is obtained through a specific way and use of the stop motion technique. Again, let's remember that there is no effective transmutations of matter, they are simply deducted and the consequences of the effects of texture and the relative consistency of materials. The virtual nature of visual phenomenon happening on screen and simulated frame-by-frame is a unique way to make analog simulations (instead of digital ones) and to play on the consistency and qualities of matter and objects more or less "taking the body".

According to me, with some stop motion productions, we are departing from the plasticity problem and are more concerned by plasmaticity for it is not only about making objects move but it is about enabling new possibilities, empowering somehow matter with new properties. It becomes possible to talk about its dialectical redefinition for objects are losing specifications at the very same moment they are earning new ones through their animation. The spectator is not only aware that a strange process impulsing things remains definitely unintelligible, he also paradoxically "gets" that the transfiguration process fall under the same category, but on a higher degree, of unreachable or ungraspable logic. However, we are led to understand that movement simulation, that was supposed to be only concerned by cinematic modifications of objects position in space and time, also compromises the integrity of the concerned objects. The required modification of shape, alteration or substitution of the object happening between two shots should be recognized as two distinct information but remain negatively identified as one because they come from one same process.

The animator, for example, can convene fluid elements by overcoming the difficulties of manipulating elements really and actually fluid. It is nearly all about confronting oneself to material issues when at the same time not having to deal with the actual constraints of fluidity for example, by finding imaginative ways, subtle effect working as solutions, to make the spectator feel it anyway. Soft matter really becomes an absolutely relative notion for the animator who has to stabilize object so that he do not miss the shot, otherwise, only solid elements are chosen to be animated. All in all, the characteristics of materials are dealt with when manipulated but won't appear as such: neither solid nor manipulated but rather fluid and autonomous. So the animator is not much a demiurge since he has to find incidental effects to express his desire: he can't realize his intentions straight forward.

The double issue of one matter and another specific time scales (respectively too long for the solid and too slow for the fluid) is in fact resolved at once. Indeed, the animator has to mobilize not really versatile materials but precisely, in the end, invests this limitation to turn it to his advantage through the filmic process. The new dynamic infused creates effects of matter all along. Here also, one matter can change relatively to strain and, as it is the case with non Newtonian fluids (counterintuitively liquid gets more solid when submitted to high strain in that case). It is like the animator, through the inter frame, gets into another dimension from where he can modulate flow times. The animation can be based on this appropriation of the benefit that result from this tension between the timescale specific to the real way of flowing of materials and the timescale deducted from flowing simulated or derived from the blended image, resulting of the frame by frame process. Objects are not liquefied in the filmic flux but reanimated according to what the animator wishes to bring forth. That way, an absent thing is nonetheless summoned on the screen.

The animator is playing on this infinite elasticity of time which is related to the inter frame. Indeed, the action on the set takes place during this suspended moment when one can take a few seconds or hours to judge what to do next, feel the objects, make his move and again judge if it suits his original vision to maybe intend something else. In this process, the matter seems to have an infinite time to flow. Such thing normally does not exist: even glass can flow and scientists never "fixed" the matter so that its microscopic absence of movement would make its temperature reach absolute 0. But once animated the status of this flow time change according to what the animator decided to do, and so we can say he controls it. The way the object move can be out of this world, but also the way one matter flows compared to how it is supposed to flow, especially if it is supposed to be solid. To recognize one matter for what it actually

was can become very difficult and that trompe l'oeil is precisely the point if the animator really wishes to use this transfiguration or transmutation potential of the stop motion technique. Symmetrically, to distort and misrepresent one matter is a way to avoid the use of too solid or too liquid substances. To go without the difficulties pertaining to the habitual manipulation of material which are difficult to handle and stabilize on the set is a real asset. The treatment of different objects individually helps to make one object behave according to what is wanted without modifying the rest of the set elements' properties. Anything can be timed and so disguised in function of what is needed, following the already very used compositing principle (being it celluloid or computer effect).

The animator is constructing an artificial set of modifications in a row. Then, the synthesis of these inter frame "strains" produce an original sense of strain for the quantitative becomes qualitative: objects or bodies seems autonomous, are moving more or less linearly, can transform or even transmute as we have seen it. A quantity of inter frames interventions resolve in a quality event and presence but also in the multiplication of materials in spite of really having them on the set, circumventing the problem and bypassing material, structural (static objects and still image) and staging constraints (material limitations) through this frame by frame arrangement, fabrication. It departs from a plastic problem, and then goes through a dynamic process to get a result or a solution which is as much plastic as it is dynamic. The animator deduces what to do with its material but at the same time induces the presence of absent material through manipulation and consequently a game of more or less difference between two shots and thus instigates a specific time variable. We can underline a relative principled indeterminacy of matter, not because it stands ontologically unqualified, but precisely because it is open to any qualification with a view to produce a plastic effect. Matter is undetermined until the animator resolves himself to qualify it.

3D and 2D animation and sometimes stop motion animation are based on compositing for practical reasons but only stop motion gives the opportunity to reanimate separately objects to eventually simulate physicality. The great response to weak strains or external solicitations explains why scientists and engineers are attracted to soft and complex matter. Through stop motion, artists do not automatically search for an ideal matter[8], in the sense that only one and the same paste, if efficiently coloured, textured and animated could accurately render one phenomenon, action or body reaction. Instead, they are looking forward to come out right on the aspect, qualities and behaviour to make the spectator feel he is in front of this or that matter and not the one really used in the process. The animator is looking for a sufficient body of evidence so that elementary indices polarize to make a credible simulation, so that he does not aim at being exhaustive. His work is based on a limited amount of materials so he also has to diversify the effects he can convey with one same matter.

To me, this body of filmic experimentation is like what physicists calls "laboratory phenomenon" for it make happen unlikely matter behaviours by experimenting on a temporal construction. The events happening on screen are only visible through this screening. The reconquered condition for the phenomenon to merge is not temperature, concentration, pressure or the effective strain, but the artificial logic of continuity found through the frame by frame process. Thus, stop motion can bring a variety of consistency, elasticity and flow for example but also instant appearance, disappearance. Such a thing is not that astonishing since the substitution technique is based on a series of appearance and disappearance (instant or happening in a very short timescale) that happens rarely in the everyday life except with technologies (such as luminous flashing, stroboscope) or rare natural phenomenon (shooting stars, lightning, will-o'-the-wisp).

A model taken from physical sciences to describe the variable character of matter relatively to time.

The common classification of matter states has been progressively updated thanks to the new understanding of the atom and most of all the discovery of subtle states through laboratory experimentation like plasma, mesomorph, supercritical, etc. But all these macroscopic descriptions have been supplanted by a new classifying system based on the analysis of the atomic structure: the ordained state, crystalline and the disordained state, also called amorphous. When molecules or atoms are regularly disposed, the physicist admits it is a solid whereas a shuffled disposition is definitely the structure of a liquid or a gas. It helps think the transitory phases which are more like ruptures as it is the case with glass or elastomers which are amorphous compose, even if these cases are more complex than traditional liquids since it goes from a viscous or rubbery state to a glassy one.

Glass is in fact a liquid which temperature has been brutally changed and decreased[9]. Depending on what time and under what condition lava flows it can suddenly become amorphous, or, on the contrary, slowly be mineralized. Viscosity or viscous milieu corresponds to the state of atoms not having enough motility to reach the structure of the crystallized solid. The vitreous state is then an extreme state of resistance to flow, or viscosity. Glass is indeed an amorphous solid that can be considered a liquid on hold and is the most common amorphous solid we actually know. The timescale used to describe of a vitreous matter could flow is so gigantic that it takes more than the age of the universe itself to actually see it spreading, so even the best timelapse would not make any difference. The only way to see it actually flow is like in the everyday life: you have to melt it under high temperature but we understand here that our notions of what is fluid or solid may depend on the timescale of the experience or on our perception. A solid is thus an ambiguous object because it can be suspended in an intermediate state, an in-between phase. One material solid appearance is based on its

stability through time, not on its strict stability at a given instant. Also, the problem is more complex than saying it is like a kind of liquid screenshot since molecules' position are still but random in time.

An instrument helps to avoid the debate on what would be the most relevant classification, especially since the discovery of these exotic states of matter, it's the Deborah number. It is a ratio between relaxation time and observation timeframe defining if a body can be said solid, relatively to the timescale instead of the crystalline or viscous nature of this body at a given moment. It is called a dimensionless number for it is not a measuring unit but can be used as a pivot point. A value superior or inferior to 1 defines if one matter is rather solid or liquid. Two quantities of the same dimension are thus strongly bounded, one relatively to the other so that we do not have to use variables. As Séon underlines it, "fluid mechanics is the most common disciplinary field to use it"[10], that's how Reynolds has been able to produce one exact same kind of turbulent flow modifying at times the speed of the flow, at times the tube diameter, at times the liquid's viscosity[11].

In stop motion, one object form or speed do not vary as it is normally the case – for instant the flow of a river in relation to its width. There is a de-indexation of covariant parameters and one solution for the animator is to indirectly redefine some kind of logic in terms of materiality when at the same time trying to simulate the physical laws ruling our everyday life.

Precisely, the ratio between a specific flow and time scale can be modified through the animation process nonetheless differently from producing a classic recording. It is the latter's thin framing that allows the kind of rewind or fast-forward effect we know so well, helping us in documentaries to get some behaviour, phenomenon or missed micro-events or details. Differently, for example, the animator can adjust the velocity – henceforth artificial – of one material's rate of warping or running, which may never happen usually. In other words, the stop motion process allows to play with streaming velocity of the profilmic elements themselves (because the filmic and profilmic are intricated) when the live action process can only impact the content of a scene as a visual effect through frame limits and camera moves relatively to moving or static elements populating this same frame. As seen previously it is possible in both slow motion and time-lapse to reveal dynamic forms but not to conceive brand new ones while the timescale resulting from the fusing of the frames is pure invention. It is not referring to the timescale on which the animator's activity on the set is based and even if frame by frame animation is very time consuming, still it is not a record that actually happened in real time. Nor does it refer to the real pace of change of things flowing or being consumed so that time scale would be then compressed or decompressed when screened. Stop motion is not about time's elasticity, being it shrinking or dilatation.

On a more theoretical note stop motion animator is more like standing at the very pivotal point where the object cannot be considered neither fluid nor solid, since he is like stuck in a suspended space-time shot after shot and at the same time in an always resuming state, frame after frame always awaiting for its actualization through the fusing effect. This game with variation does not resolve in the simulation of movement or formal diversity, it can also produce the simulation of material qualities to be found in the specific relation between the experience time (or the visual experience) relatively to relaxation time. On a more abstract note let's say that when in nature everything is flowing more or less slowly, through the stop motion technique the animator institutes a rule bounded by two extremities where the cursor location oscillates so that on one end it is possible to make any matter fluid (to the point of suprafluidity) regardless of its factual solid state on the common human perception timescale, and to another end any matter may become inert despite the supposed fluidity we are used to experience with the chosen soft matter or fluid. Not only the animator can put on hold the physical rules but he can take hold of matter and deprive it from some or all of its unique characteristics.

Conclusion

Patar and Aubier, while working on *A Town Called Panic*, being it the TV series, movie or shorts produced since 2002 and ongoing, are not aware of how systematically they convert matter into another to simulate the full presence of an object on screen, absent from the film set. What could be thought only as punctual tricks, effects or specific editing into the stop motion film, just like the live action film has his own smoke and mirrors and editing effects, constitute in fact the specificity of the medium entirely. As a matter of fact, any animated object on the set could be subject to such material distortion, not only elements like water, fire, smoke, mud, snow or furs for examples. Yet it has to be said that since the first wave of stop motion feature film rising production at the end of the years 2000 and its second wave in the beginning of the 2020 decade, we haven't spotted a new trend going in the direction of such developments though, but mostly the contrary with more staging and mechanical props or digital effects introduced as solutions to formal issues that could be resolved precisely through the animation process in itself. Let's hope this paper will help understanding the empirical process of animating to definitely open up the field of stop motion technique when seen as an analog simulation.

As we saw it, stop motion's inter-frame composition allows to play on temporality so it becomes possible to do as if, what used to appear solid could suddenly come to liquefy, keeping at the same time the indices of our habitual everyday life timescale. In other words, it is as if, within or from a timescale looking like our perceptive everyday experience timescale, we could experience either things taking an eternity to flow, either on the contrary things, phenomenon or events running quickly but also and above all matter properties one fluid

do not own normally. The flow or deformation effect constitutes a new condition for matter and amounts to simulate and render present materials actually absent from stage for they are too difficult to animate as such. More precisely the whole process is removing the logic of continuity from which our senses are based on in the common experience of flows.

According to me, all these considerations make it possible to avoid an analog, metaphorical or figurative discourse which, while illustrating this poetical laboratory that a stop motion workshops and sets constitutes, does not reflect the fact an image is not only summoning a world, it is also a derealisation of the world we know and only model we have. To this end, the method used here is inevitably specific and proceeds from the animator's action or response and to the frame-by-frame composition. It also depends on the animator's capacity to mentally visualize which series of modifications will lead to simulate one matter behaviour or another first. Otherwise, his skills also rely on a body of knowledge. Indeed, the animator processes more or less consciously the idea that some physical phenomenon, yet commonplace but complex, are most often counterintuitive. As seen above, they can be relative to a particular kind of strain or to time.

Final Notes

[1] http://www.theses.fr/2021PA01H301

[2] Most flows experienced in everyday life are turbulent flows. Laminar flows are mainly artificial and are not surprisingly spectacular.

[3] In comparison, according to a 2013 study, human visual perception should be able to get a frame each 13 milliseconds, or 76 frames a second. For more details check: POTTER, Mary C., WYLBE, Brad, HAGMANN Carl E., McCOURT Emily S., Detecting meaning in RSVP at 13 ms per picture, Attention, Perception, & Psychophysics Journal, 28 décembre 2013, https://tinyurl.com/y6gjg5w6.

[4] In the exhibition *Effets spéciaux, crevez l'écran !* which happened in 2017 from october 17 to august 26 at the Cité des sciences de la Villette in Paris, Réjane Hamus-Vallée wrote CGI generators "are using algorithms close to the ones created by scientists for meteorology, computational fluid dynamics, kinetic theory of perfect gases, for examples." Yet there still is no such thing as equation describing most of the flows encountered in the everyday life because of their complexity notably due to viscosity parameters. Thus, numerical modelling can only roughly approach, except through statistical models, a virtual simulation of the bulk behaviour of most materials. To me, it explains the low level of technical development, in terms of fluid dynamics, of cinema and video games CGI whereas photorealistic elements (lights, gradients of texture) are always evolving. By comparison stop motion definitely stands as an analogic way to simulate and display such matter behaviour without resorting to a mathematical arsenal.

[5] We have to consider that viscosity concerns every material because it is an intrinsic property defined as the degree of flow resistance, or fluidity.

[6] Fluid dynamics are most often dealing with non Newtonian fluids. In fact, most material flows are not only related to pressure and temperature variation but also strain (shear stress) and speed. Moreover the deformation does not vary necessarily proportionally to the force applied. Rheology or the study of material flow is not all about solid's plasticity but also and especially complex fluids like non Newtonian ones.

[7] Kinetics is about an effect of motion and covers the study of body dynamics but also more specifically, in the field of thermodynamics, aims to quantify the energy developed (amount of movement that can induce mechanical work) or to describe the properties of bodies varying with the microscopic internal movement (molecules in motion in a gas). Kinematics, on the other hand, aims only at describing the movement of an object through space and designates a persistent or invariable solid that travels through space while taking time. Motion-capture, for example, is using kinematics models describing the evolution of one point in space via the concepts of trajectory, vector, speed or acceleration/deceleration in a time as graduated as space is. Kinetics, for its part, is defining an alteration of an object when its behaviour is changed because of mechanical strain, pressure or temperature. It can be described independently of the simple dynamics of its journey through space.

[8] Being it resins, gelatines and rubber latex then polymers or elastomers, materials science is always striving for intermediate materials concealing the wanted properties between solid and liquid. On that note, plastics processing offers a set of technics innovating more cost-effective and ergonomic dummy materials.

[9] BALIBAR, Françoise, *La science du cristal*, Paris, Hachette, Collection Villette Cité des sciences et de l'industrie, 1991, p. 50.

[10] SEON, Thomas, *Les lois d'échelle, La physique du petit et du grand*, Paris, Olide Jacob, Collection Sciences, 2018, p. 154.

[11] *Ibid.*, p. 163-165.

Bibliography

Balibar, Françoise, 1991, *La science du cristal*, Paris, Hachette, « Villette Cité des sciences et de l'industrie ».

Carpentier, David, 2017, In *La Recherche*, n° 530.

Mitov, Michel, 2010, *Matière sensible, Mousses, gels, cristaux liquides et autres miracles*, Paris, Editions du Seuil, « Science Ouverte ».

Potter, Mary C. and Wylde, Brad and Hagmann, Carl E. and McCourt, Emily S., 2013, *Detecting meaning in RSVP at 13 ms per picture*, In *Attention, Perception, & Psychophysics Journal*. https://tinyurl.com/y6gjg5w6 Last access on 30/11/2020.

Séon, Thomas, 2018, *Les lois d'échelle, La physique du petit et du grand*, Paris, Olide Jacob, « Sciences ».

Wells, Paul, 2010, *Les fondamentaux de l'animation*, Paris, Pyramyd.

Filmography

A town called panic (TV series). (2005)., Directed by Vincent Patar and Stéphane Aubier., FRANCE: Studio Canal. DVD.

A town called panic (Film). (2009)., Directed by Vincent Patar and Stéphane Aubier., FRANCE: Wild Side Video. DVD.