CARTOON PHYSICS FOR COMPUTER-ASSISTED ANIMATION

Location: Inria - Univ. Bordeaux, MANAO research team (http://manao.inria.fr)
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Motivation and Context

2D animation as an art form has experienced drastic changes since its dawn. Starting with early traditional animation with every frame drawn, to modern vector animation, its mainstay attire is virtually unconstrained artistic expression. Existing alongside its 3D counterpart, modern 2D animation borrows many tools from 3D, such as rigging, skinning, and deformation, but offers a different fine-grained medium for expression, allowing to control each vector stroke.

In this context, the animation of secondary motions (such as hair waving or clothing movements) and of special effects (e.g., fire, water, smoke) is usually done manually by redrawing strokes on each frame, a time-consuming, tedious and cumbersome task requiring precision and training. The ultimate goal of this project would be to enable artists to easily add complex secondary effects, such as fire or smoke, cloth animation, or soft tissues (e.g., belly jiggling) to their 2D or 3D animations, while providing full control over the results.



Figure 1: *Frame from the 2D vector animated sequence "Billie" ©2023 by Les Fées Spéciales.*

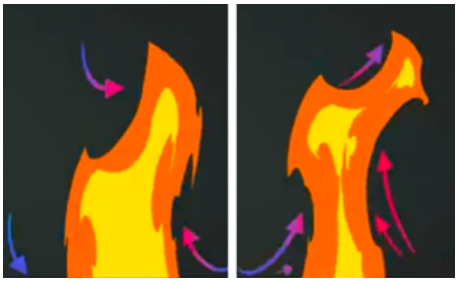
Realistic movies, whenever they use computer graphics, target realism and hence simulate real physics. On the contrary, many motions in traditional animation follow *cartoon physics*. Cartoon physics is deeply rooted in real physics, but allows for artistic license, often in the form of animation principles such as squash-and-stretch, anticipation, etc [1]. This applies to inanimate objects as well, such as animation of fire and smoke or clothing, which often exhibits stylized and exaggerated physical motion. Previous approaches tend to explore either fully physical [2] or fully stylized 2D animation effects [3], neither of which are satisfying for animators.

Objective(s)

Two separate research directions may be explored during this internship according to the candidate's preference.

The first one consists in exploring the creation of **3D special effects animations**, with the aim of achieving stylistic control over movement using an approach inspired by traditional 2D animation. Based on previous studies and experiments, we decided to break down the effect's motion and shape into three scales, and provide controls tailored to the first two scales: direct control over the effect's primary movement, by combining procedural animation techniques with manual adjustements, and semi-automatic control over secondary movements through deformation skeletons. The third, finer scale defines the effect's final silhouette which is shaped by external forces

(e.g., hot air convection for a fire) and the artist's intended style (ee Fig. 2). Developing algorithms to automatically generate and tools to control this scale could be the main focus of the intership. In practice, these developments will leverage our current prototype which relies on the open-source 3D rendering and animation software Blender.



(a) Air convection curves the negative space, shaping the fluid over time.



(b) Different shape languages, based on the same underlying structure (left), produce different styles.

Figure 2: *2D fire animation tutorial, ©C. Cordonnier.*

The second research direction aims at studying, modeling and capturing the fine balance of **cartoon physics** in 2D animation. The overall approach is to develop and implement an algorithm for secondary animation of 2D vector characters and inanimate objects, combining physics-based animation with artistic stylization and control (see Fig. 3). The proposed approach involves attempting to reproduce traditional 2D animations with secondary effects (e.g., character's tail, clothing) using an inverse physical simulator, by first varying the physical parameter throught time, and then gradually introducing "non-physical" components (e.g., disregarding energy conservation, adding virtual forces) until the two match. The challenge will then be to extrapolate or generalize these non-physical terms to subsequent parts of the same animations and even new ones.

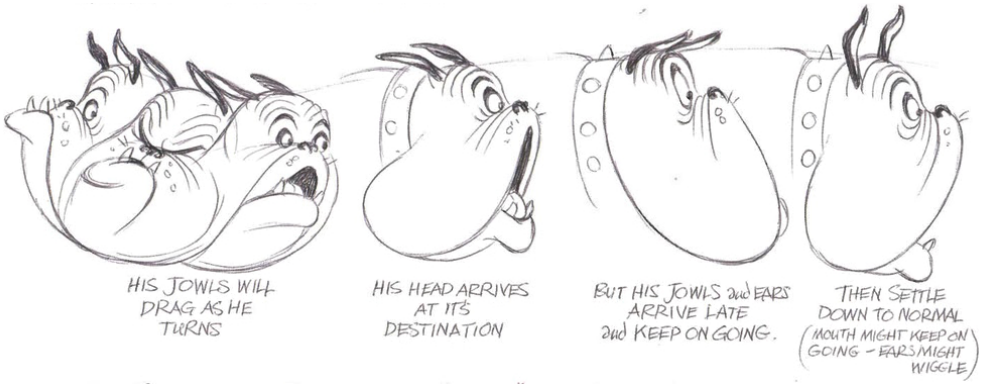


Figure 3: *Anticipation and follow-through, from "The Animator's survival kit" ©2001 R. Williams.*

Expected Skills

The successful candidate should have taken Master courses in Computer Graphics (including physical simulation) and have a strong experience in Python programming. Additional skills in some of the following topics would be appreciated: numerical optimization, user interface. Personal interest for drawing or animation would be a plus.

References

[1] F. Thomas 1912-2004, "The illusion of life : Disney animation." 1st Hyperion ed. New York, 1995.

[2] J. E. Zhang, S. Bang, D. I. W. Levin, and A. Jacobson, "Complementary Dynamics," ACM Trans. Graph., vol. 39, no. 6, pp. 1–11, Dec. 2020, doi: 10.1145/3414685.3417819.

[3] Z. H. Ibrahim, "The stretch-engine: a method for adjusting the exaggeration of bipedal characters through squash and stretch," in Proceedings of the ACM SIGGRAPH / Eurographics Symposium on Computer Animation, New York, NY, USA July 2017, pp. 1–2. doi: 10.1145/3099564.3106639.