



# How to Make a CG Video

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## Abstract

In this video we describe why producing a Computational Geometry video is a good idea, what it takes to make one, and how to actually do it. This includes a guide for the overall process, a number of examples, and a variety of tips and tricks.

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**Category** Media Exposition

## 1 Introduction

Developing and communicating abstract concepts is one of the fundamental capabilities of humans that distinguish them from other beings [20]. For tens of thousands of years, this communication was based on direct human interaction; one of the crucial breakthroughs of humankind was the development of methods that allow conveying information by other means, in particular, by written language [21]. This has allowed spreading and preserving information and ideas, independent of physical presence.

In this evolution, mathematics has been at the forefront of exploring and expanding the realm of abstract concepts; moreover, the development of mathematics has greatly benefitted from a rigorous separation of human emotions and experience from logic and truth. As a consequence, many mathematical ideas are difficult to convey and comprehend; however, in the words of Terry Tao [22]: “There’s more to mathematics than rigour and proofs... The point of rigour is not to destroy all intuition; instead, it should be used to destroy bad intuition while clarifying and elevating good intuition.”

What are the best ways to convey mathematical ideas and intuition? While human brains have dealt with visual information since the beginning of humankind, processing letters and mathematical notation has been a very recent development. Moreover, the evolution of visual information processing by humans has largely been fueled by the need to recognize the position, motion and interaction of objects in space, so the affinity of human brains to geometry is deeply rooted [2]. Therefore, it is quite natural to make use of geometry to convey mathematical ideas – in particular, in the field of geometry itself, as demonstrated by the visual power of Byrne’s classic illustrated version of Euclid’s elements [10].

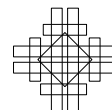
Over the years, many other scientific areas have contributed to advances in visualization [18, 19], at the same time demonstrating the power of turning complex information into convincing geometric representations. This development has been fueled both by the need for processing and representing large amounts of data, as well as the availability of more and more powerful computational devices, algorithms and interfaces.



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## 2 Videos in Computational Geometry

All this makes it natural to use dynamic visual presentation of concepts and ideas in Computational Geometry. Now in its 29th year, the multimedia track of SoCG has demonstrated how videos not only allow making use of dynamically changing objects, but can also make use of the fundamental concept of storytelling, already mentioned above [21].

There are a number of other good reasons for capturing and visualizing scientific ideas in the form of videos. They allow presenting results and ideas in a *dynamic* fashion, instead of statically as on paper; because they allow demonstrating how things really work, they are more *convincing*. With concise and well-planned presentation, they are also *compact*, allowing them to present ideas and results in just a few minutes.

Particularly important is the *portability* of digital content, which can travel large distances without requiring physical presence. While this video was designed and submitted before the onset of recent world events, the new reality of social distancing and remote teaching has made it irrefutably clear that the need to convey complex ideas without direct human proximity will greatly benefit from a large spectrum of methods for digital representation.

Other benefits of a video are a lasting, *memorable* impression, and the *reproducibility* of running it. Finally, the process of carefully planning and producing a video is also *inspiring*, helping to make regular talks better. This is particularly true for long-distance presentations, which benefit from mastering all aspects of the involved technologies, a clear, crisp delivery, and the ability to quickly turn a talk into a video production when a conference moves from physical to virtual presence. A good example was the 2020 *European Workshop on Computational Geometry*, for which 77 talks were turned into videos within just three days [11].

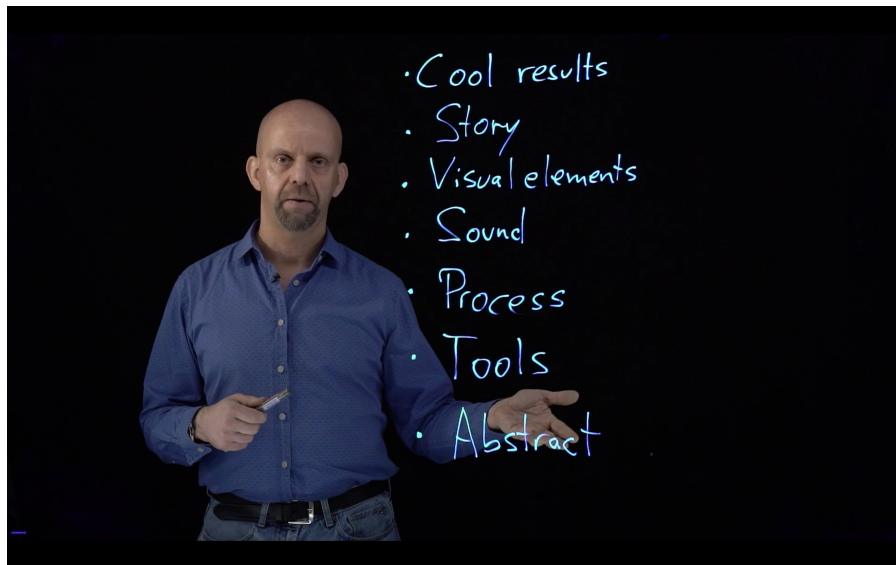
The process described in the following is based on the experience of producing a number of SoCG videos [15, 16, 9, 4, 5, 6, 7, 14, 13, 1, 3]), as well as serving on several multimedia committees. There is a wide range of other tools that can be used, and the need for remote presentations will lead to further progress; however, the underlying process of planning the story, planning visual elements, sound, process and mastering the tools is pretty much independent of those specifics.

## 3 The *How to video*

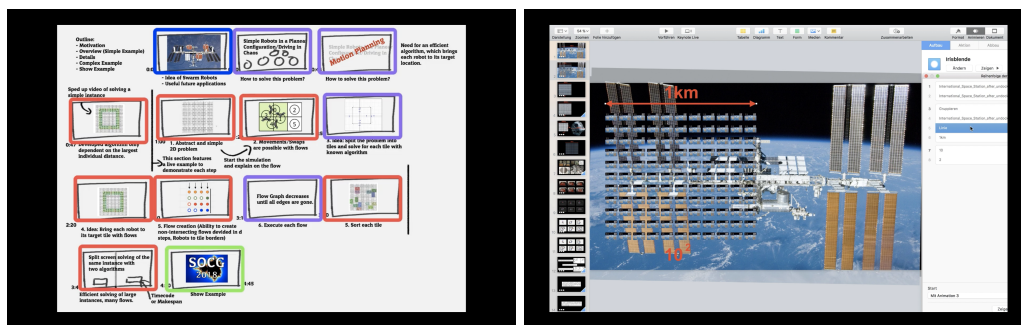
The video starts with a number of introductory scenes filmed in front of a *lightboard* [8], an illuminated piece of glass that can be used similar to a whiteboard, with the speaker facing the camera; see Figure 1. This produces mirror-inverted writing, which is flipped in video editing. After an initial motivation for producing videos, the main components are introduced: results, story, visual elements, sound, process, tools, and abstract.

The following part discusses putting together the story, based on combining key ideas with visual elements and developing an overall plot. A top-down approach for structuring a screenplay is recommended, which is then refined with a storyboard for planning the visual elements (Figure 2 (Left)). These are discussed in the context of presenting mathematical results (such as the ones from paper [12] and video [13]), in particular, turning ideas into dynamic visualizations, and presenting mathematical theorems as *images* of mathematical theorems. This is followed by a demonstration of how effective use of sound can turn even a simple sequence of images into a story, and by a brief glimpse at a completed screenplay.

The next step focuses on producing animation based on standard presentation software, such as Keynote or PowerPoint, which are then exported into a video format or converted by a screen capture; the particular demonstration visualizes the dimensions of large-scale structures in space (as shown in Figure 2 (Right)), which is part of the SoCG video [1].



■ **Figure 1** Lightboard presentation: components for making a video.

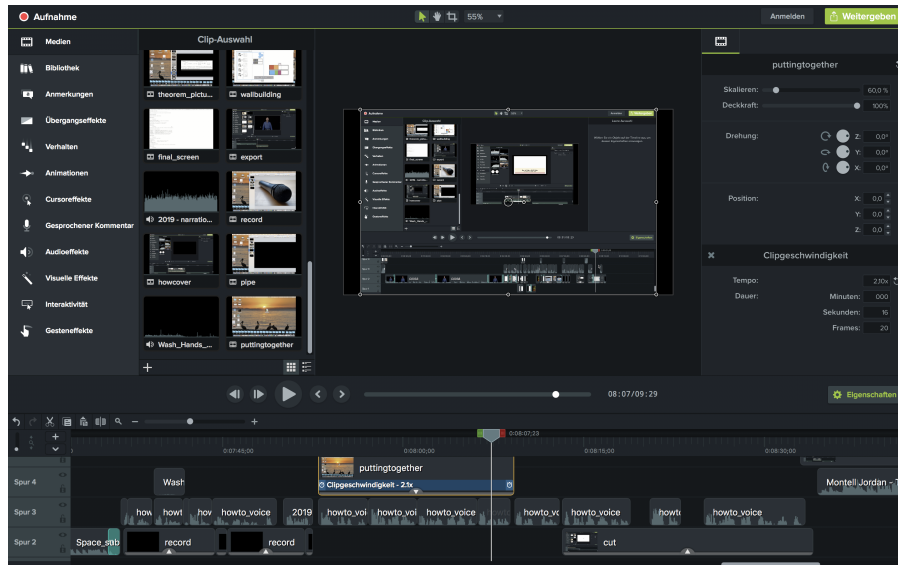


■ **Figure 2** (Left) A storyboard for the video [6]. (Right) Generating animations for the video [1].

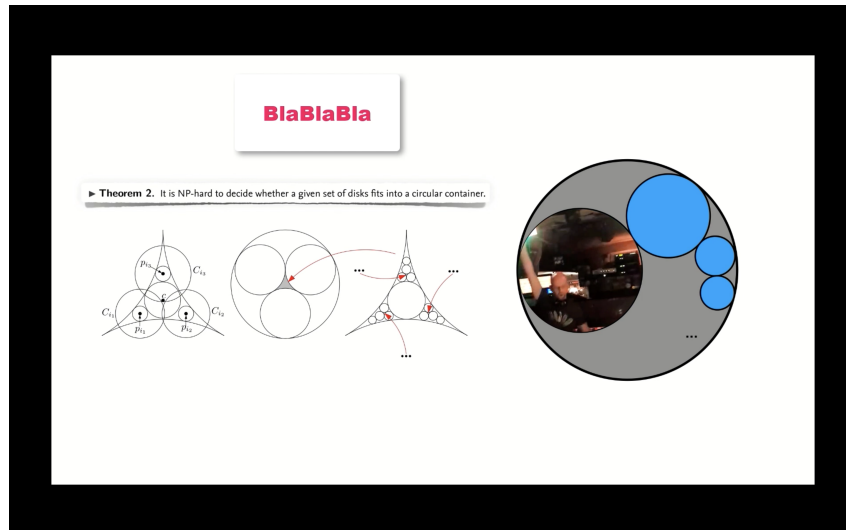
This is followed by recommendations for producing the voiceover. A particularly helpful tip is to simply record the sound by itself in one continuous session, without the need for completely avoiding coughing or misspeaking, or synchronicity to animations: If an error occurs, there is no need to start over; it suffices to simply repeat the line until it is correct. Any issues can be worked out later in video editing.

The remainder deals with tools and processes by showing a variety of capabilities of a good video program, demonstrated in Camtasia as a concrete example. The main focus is on editing sound and video to create a well-synchronized movie, described for major parts of this “How to” video itself, as shown in Figure 3. The first step consists in cutting video and sound into relatively small individual pieces, which can then easily be arranged appropriately. In most cases, it works best to let the sound be the guide for the timing of the video, as it is easier to speed up or slow down the latter; this is demonstrated with the opening of this very video, for which the animation steps are synchronized to the beats of the music. Another tip is the combination of different video elements (such as slides, real-world video, and labels) into the same scene; a demonstration uses a snippet of a mathematical talk [17] with a dance video featuring one of the authors (Figure 4). Finally, everything is exported into one integral video.

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■ **Figure 3** Four levels of editing for this video, shown in Camtasia. (Level 0, white rectangle) The title sequence for this video. (Level 1, inner black frame) Editing the title sequence. (Level 2, medium black frame) Showing how to synchronize sound and video in the title sequence. (Level 3, outer black frame) Screenshot of editing Level 2 for this video.



■ **Figure 4** Combining multiple elements in the same scene with the help of a video editor, such as a slide, a label (“BlaBlaBla”), and some real-world video.



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