Production of lecture videos with green screen technology

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Abstract

Sollen Vorlesungsvideos zum Download oder als Livestream mit guter Qualität produziert werden, ist die Einrichtung eines Videostudios unumgänglich. Der Aufbau eines Studios mit einfachen Mitteln in einem umfunktionierten Seminarraum wird beschrieben. Dabei kommt Greenscreen-Technik zum Einsatz. Diese ermöglicht es, den Sprecher oder die Sprecherin vor seine digital generierten Inhalte zu stellen und ihn wie vor einer klassischen Tafel agieren zu lassen. Erfahrungen bei der Einrichtung und dem Betrieb des Studios werden dargestellt sowie eine Bilanz nach mittlerweile ca. 100 produzierten Lehrstunden gezogen.

If lecture videos are to be produced for download or as livestream with good quality, the establishment of a video studio is inevitable. The set-up of a simple studio in a converted seminar room is described. Green screen technology is used. This makes it possible to place the speaker in front of his digitally generated content and let him act as if he was in front of a classical blackboard. Experiences with the installation and operation of the studio are presented and conclusions are drawn after approximately 100 hours produced lessons.

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1. Introduction and retrospective

Within the framework of online teaching, videos for lectures, exercises and similar formats have been produced by the staff of the Chair of Dynamics and Mechanism Design since the summer semester 2020. From the very beginning, the lecturers at the chair have been using digital lecture formats, which they have been used to for years, in a video presentation. Lectures at the professorship often consist of a mix of "live" handwritten parts based on Microsoft OneNote on a tablet PC and PowerPoint slides, with handwritten additions if necessary. In the summer semester 2020, this form of presentation was implemented with the help of the video production program Open Broadcaster Software® (OBS), partly with the inclusion of a small lecturer video (Fig.1Fig. 1).
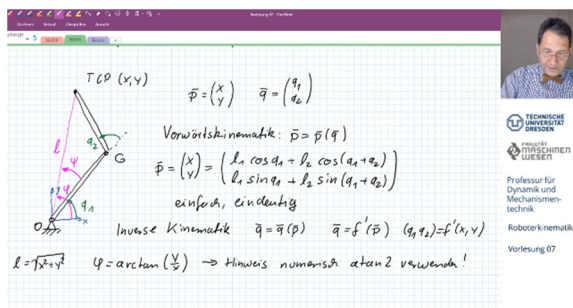

Fig. 1: Screenshot of a conventional teaching video with small lecturer image

In the summer semester 2020, the videos were generally produced by the lecturers in their home offices. Although this worked well, considering the short preparation time, from the authors' point of view it has the following disadvantages:

- The quality of private cameras, e.g. a laptop camera, is not optimal. Moreover, in the summer of 2020, it was virtually impossible to buy cameras.
- High-quality sound requires good microphones. These were also either not available or not procurable.
- It was not possible for the lecturers to have a set-up in the home environment where they could produce the videos in the better speaking posture while standing.

- When producing elaborate scenarios, e.g. with the integration of an experiment, a recording assistant was missing.

In order to eliminate the disadvantages mentioned above, we decided to set up a studio in the facilities of the professorship where the lecture videos could be produced in a more professional environment. For this purpose, a seminar room that used to be suitable for up to 30 students, was converted. There, the lecturers can either record videos that are later offered for download or produce live streams that are broadcasted via online platforms such as YouTube. Extensive use was made of both formats from the 2020 winter semester onwards.

2. Green screen technology

The authors are convinced that a lecture video gains massively in quality if the person speaking can be seen in the video. The reasons for this are as follows:

- Speech comprehension increases when the facial expressions and mouth movements of the person speaking are visible. This is particularly important with regard to non-native-speaking listeners and for English-language lectures of the professorship.
- The speaker can underline his or her remarks with gestures. It is also possible to include demonstrations and experiments.
- The commitment of a lecture increases when a speaker is visible and not just sound coming from the "off".

Modern television studios today are usually green screen studios. The studio is largely empty and equipped with a green back wall or even a green floor. With this technique it is possible to record the person speaking in the foreground, "crop" it and fade in arbitrary content in the background.

The green screen technique as a form of "chroma keying" is based on digital image processing. In this process, the video software detects the uniform green colour in the back-

ground of the main video and treats these areas as transparent. This image can now be digitally placed in front of any other static or moving video image.

This technology was also used for the videos of the Chair of Dynamics and Mechanism Design. This makes it possible for the lecturers (Fig. 4) to act in front of their content as if in front of the classic blackboard. For example, the hand can be used to point to virtual content in the background (Fig. 2).

The authors hope that this will make the videos particularly lively. This technique is used on television for weather forecasts, among other things, when meteorologists present in front of a weather map that is only virtually shown.
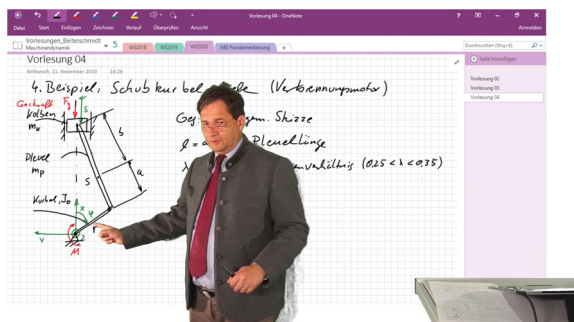

Fig. 2: Possible action of the lecturer in front of the background image. A "shadow" can be seen on the lower back area, which is caused by less than optimal illumination.

3. Arrangement in the studio

As already mentioned, a green background is required. It was decided that only the upper body of the teacher should be visible, as this is sufficient for a university course. Thus, only a hanging green curtain from ceiling to floor is required. Suitable fabrics are available from specialist video equipment distributors.

For a good result, it is necessary that the green background is illuminated as uniformly as possible. This requires several spotlights, as even the shadowing by the speaker can distort the green tone of the background in such a way that the video software no longer clearly recognises it as a "background" (Fig. 2).

For good acting in front of the camera and pointing on the virtual content, it is very im-

portant that the speaker can see itself. For this purpose, a 65-inch TV was set up directly opposite the movement zone as a control screen.

The best camera position has turned out to be a mounting at the upper center of the control screen. This is similar to the function of a teleprompter, because when the speaker looks at the control screen, he or she automatically looks at the camera.

The speaker is placed to the side behind a pen tablet on a lectern. The purpose of this is that the person presenting usually stands at the side of the image and does not cover the content on the virtual board. For pointing and interacting with the image, the lecturer can leave the lectern and step in front of the virtual image (movement area in Fig. 3).

For the sound recording, a RODE-NT-USB microphone on a stand as well as a Sennheiser EW 100 G3 clip-on radio microphone are used. Behind the screen, at an appropriate distance, is the operator desk. Here, a recording assistant can take a seat to monitor the recording process, switch between recording modes, alert the speaker to content-related and technical faults and, in the case of live streams, coordinate communication with the audience. The layout of the studio is shown schematically in Fig. 3. Unlike the symbol representation in Fig. 3, modern LED panels instead of classic headlights are used. However, the arrangement is shown correctly: A main light source directly above the control screen illuminates the person speaking. Due to the width of 30 cm of this panel, a sharp silhouette of the person is already partially softened. The two lateral spotlights illuminate only the green wall behind the speaker to further reduce the shadowing.

Fig. 4 shows the inside of the studio with a lecturer. Above the control screen, the camera and the main light source can be seen. One of the two lateral light sources (small white rectangle highlighted with the red circle) has been switched off for the photo to avoid backlighting in the picture. That is why the shadow of the person on the green wall is relatively sharply visible. On the control screen, the lecturer can see the completed composite video image.
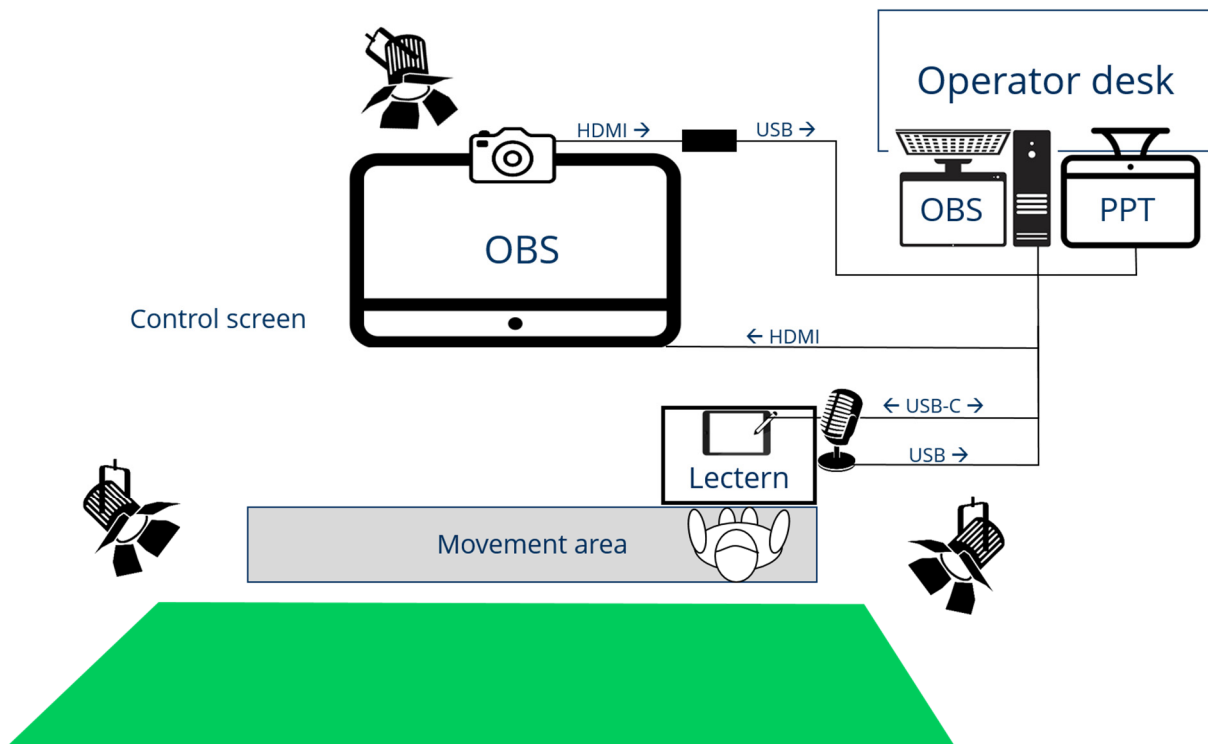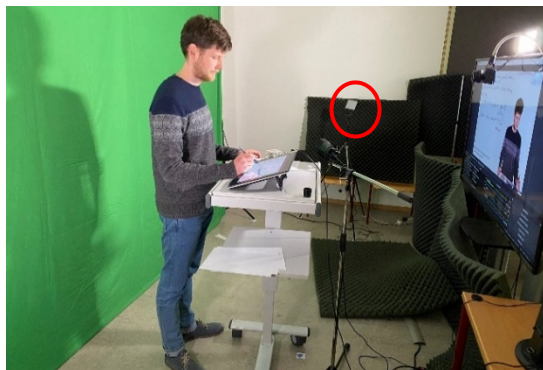
Fig. 3: Top view of the studio

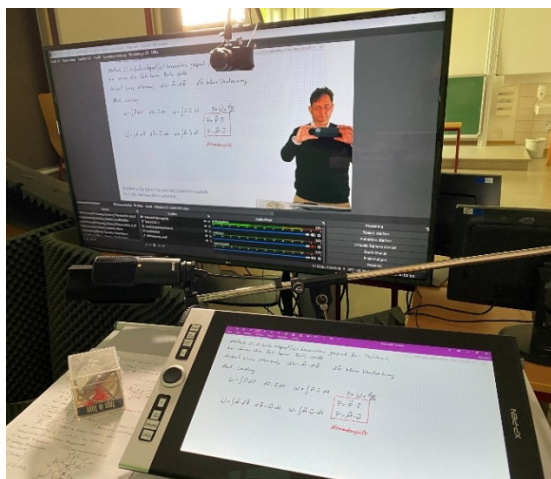*Fig. 4: Picture from the studio (Photo: M. Beitelschmidt)*

Fig. 5: Perspective of the speakers (Photo: M. Beitelschmidt)

Fig. 5 shows the perspective of the lecturers in the studio. In front of the lecturer is the tablet on the lectern, behind it is the microphone mounted on a tripod. Opposite is the control screen on which the lecturers can see themselves as if in a mirror.

4. Software and hardware

The entire recording technology is controlled by a standard PC, which is operated by the recording assistant. The microphone and camera are connected to this PC via an HDMI-USB converter. The pen-sensitive tablet (XP-Pen Innovator 16) on the lectern is connected to the PC via USB-C using an adapter (Fig. 3). The OBS software used on the computer has the green screen functionality. The PC is equipped with an Intel Xeon E6-2667 processor (3.2 GHz) and has 32 GB of RAM. However, the performance of the device is not fully utilised during video recording. Four screens are connected to the PC:

1. On one screen, the assistant can see the OBS interface.
2. The second screen is the presenters' control screen (large screen TV), onto which

the assistant screen with the OBS interface is duplicated.
3. A third screen displays PowerPoint presentations.
4. The pen tablet is another screen.

The operation of the four screens is possible with the video outputs available on the PC, one DVI output and two DisplayPorts. Screens 1 and 2 receive the same signal via DisplayPort, which is duplicated by an external splitter. Screen 3 is connected to the DVI output. The tablet as screen 4 is connected to the second DisplayPort with a special adapter.

As mentioned in the first section, two main display modes are used: In OneNote mode, the presenters see their OneNote page on the tablet and can write in it with the tablet pen. OBS picks up this screen and makes it the screen background in front of which the cropped speaker video is placed.

In PowerPoint mode, on screen 4 the presenter view is used, and on the third screen, the presentation is displayed, which is picked up by OBS. This is then again overlaid with the speaker video.

Table 1: Approximate acquisition costs of the most important hardware components

Device	Type	Price
Camera	*Sony Alpha 6000*	500€
Micro-phones	*RODE-NT*	150€*
	Sennheiser EW 100 G3 (with portable transmitter and receiver)	700€*
Tablet	*XP-Pen Innovator 16*	500 €
65 inch screen	*LG 65UK6400*	700€*
Lights	*Walimex Pro Nova 300 or 150*	160€
Back-ground	*Neewer 2.6 x 3 m Greenscreen*	110€

*did not need to be procured

With the help of pre-assigned function keys on the tablet (Fig. 5, left edge of the tablet), the speaker can also switch independently between the modes and start, stop and pause the recording. For simple recordings, this can even eliminate the need for assistance. The pause function can be used by the speakers, for example, to prepare texts or illustrations in OneNote "offline" and then explain them while the video is running, which increases the liveliness.

Table 1 shows a list of the approximate costs for setting up the studio. In addition, there is the described PC, HDMI and USB cables as well as two ordinary 24" screens. Tripods for microphone and spotlight were already available at the professorship.

5. Experiences

In principle, it was quickly possible to produce good videos in the studio. A first insight concerned the camera: a normal "webcam" is not sufficient for a good cropping of the green background. Even if it delivers a high-resolution image, image noise causes problems when cropping. A Sony Alpha 6000 camera with full HD video resolution turned out to be very suitable.

No optimum has yet been found for the microphones. For speakers who mainly stand at the lectern and do little in front of the background, the stationary microphone on the stand in front of the lectern provides the better sound. If the speaker moves away from the lectern a lot, the plug-in wireless microphone is probably the better choice.

After the production of the first lecture series, it became apparent that, regardless of the choice of microphone, there was too much "reverberation" in the sound. This is certainly due to the fact that the seminar room, which was converted into a studio, essentially has six reflective wall, floor and ceiling surfaces.

Therefore, sound-absorbing material was installed in the studio (partly visible in Fig. 4 and Fig. 5). This has been and is still being done experimentally. A measurement, e.g. of the reverberation time with different arrangements of the absorption materials, has not yet been carried out. Acoustic optimisation of the studio is still in progress.

A big challenge for the lecturers is to interact with the preview image on the control screen.

This is the only way they can point to contents on the superimposed presentation (Fig. 2). For this, it is necessary to show the presenters their own mirror image on the control screen (Fig. 5). However, since all content (texts etc.) should be laterally correct, it is necessary to mirror the speaker in the video. For the viewers, a mirror-inverted image of the speaker appears in the final video. In the chosen arrangement, viewers see the presenter pointing with the "right" hand, but in fact the left must be used, which requires some practice for right-handed people. Particularly tricky are the hands used to indicate turning movements or the "right-hand-rule", as these have to be performed in the opposite direction.

The technology is used both for recording asynchronously provided videos and for producing livestreams. The OBS software offers an interface for YouTube for this purpose.

After the asynchronous content has been recorded, it is subjected to a simple post-processing with the open source software ShotCut, in which the footage can be edited and any major errors can be removed. The production can thus be described as "live on tape".

Since the studio is set up in the building of the professorship, it is easier to incorporate demonstrations and experiments from the inventory into a video than to transport corresponding material into a lecture hall (Fig. 6). This will be used more intensively in the future.
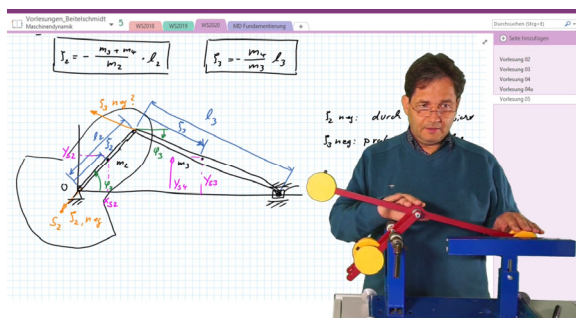

Fig. 6: Demonstration of an experiment in the lecture video

For the following courses, videos were produced in the studio during the winter semester:

1. "Maschinendynamik" (Machine dynamics)
   - 20 h Lecture
   - 10 h Central Exercise + Exercise Introductions
2. Coupled Simulation/Real-Time Simulation (held in english)
   - 14 h YouTube livestreams
3. „MKS in der Fahrzeugtechnik" (Multibody systems in automotive engineering)
   - 10 h lecture + exercise introductions
4. Introductions to online laboratory courses

Overall, the authors and other members of staff at the Chair of Dynamics and Mechanism Design value the use of the studio technology as a great step forward, with which high-quality videos could be produced in the winter semester of 2021. The positive feedback from the students, both individual statements and the teaching evaluation, also confirm this view.

The studio will continue to be in use in the summer semester of 2021.

Acknowledgement