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MODELING OF A VIRTUAL PRINTING MACHINE FOR INTERACTIVE E-LEARNING APPLICATIONS

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Introduction

The paper presents the development of an educational tool for the Roland Versa UV LEC540 digital machine, featuring its basic functions, which are animated and integrated into a web application to maximize student access. The key animated actions include loading ink into the machine, printing, die-cutting, and cleaning the print heads. Following the modeling phase, animation was applied, involving both the camera and the machine's moving parts. To enable interactivity within the application, separate 3D animations are created, which can be activated by the user through the web interface. The user selects which part of the machine to activate or which function to view. After viewing the animation, the user can repeatedly activate specific machine functions to understand the device's operation better. This method provides insights that are not easily achievable through traditional learning and are often difficult to comprehend. Additionally, the virtual machine cannot malfunction, pose any danger to the user, or consume expensive resources such as paper and ink to demonstrate its functionality.

Problem Description

Distance learning proved its importance during the 2020 pandemic, but its relevance extends beyond that period. It is a form of education where the main elements involve the physical separation of teachers and students during instruction and various technologies to facilitate communication between them. It has primarily focused on non-traditional students, such as full-time workers, military personnel, and individuals with family obligations, providing them the flexibility to pursue education while balancing other responsibilities (Berg & Simpson, 2024). It usually emphasizes the lack of personal contact between participants as the greatest shortcoming of this type of learning (Kalamković, Halaši & Kalamković, 2012). Students who may or may not be physically present in the classroom can virtually access elements they do not have adequate access to in the real world. Even when a physical machine is available, only a few students can gather around it, meaning others lack a clear view, cannot hear the instructor well, or are unable to approach the machine. In education, VR offers significant support for learning. By using such systems, students can visualize abstract concepts, observe events from different perspectives and scales (for example, atomic and giant scales), visit environments, and interact with events remotely (Machado, Costa & Moraes, 2006). Some studies, through informal interviews with students, have shown that most enjoy and appreciate 3D environments (Dickey, 2005).

Methods

Using knowledge of 3D modeling and a previously made 3D model of a machine, combined with animation, creates a 3D animation that can be used as a learning tool. To make this tool interactive, it is developed as a web application where animations start and end with the same initial/final frame to ensure smooth transitions between animations without interruption.

Results

The animation is divided into four main parts, which are integrated into a single educational tool, forming a unified whole that simulates the operation of the printing machine. Separate animations are created for loading ink into the machine, printing, die-cutting, and cleaning. Each camera for the selected machine operations follows a unique path. Special attention is paid to each camera path to avoid sudden turns and stops so that the movement does not appear abrupt or unexpected to the viewer.
Each animation has something unique that sets it apart from the others. The animation is rendered from the 3D program as a sequence of images, and then combined in the web application. It is important to ensure that the beginning and end of each animation align perfectly to avoid discontinuities in the video sequence. The resulting video is then added to the render queue to be processed in the appropriate format. The format generated this way is .avi, and additional software or extensions are required to convert it into .mp4 format.
Once each animation has been converted into a video, it must be merged into a single interactive video, which begins in the same way as each animation – with the first frame. The application is formed by defining a reference to a tag in the HTML itself , *initialVideoRef*, and the HTML will always display the initial frame of the animation, as later shown in the code as: *<video ref={initialVideoRef} controls={false}>*.

```
const [video, setVideo] = useState<string>('');

const initialVideoRef = useRef<HTMLVideoElement>(null);
const stampaVideoRef = useRef<HTMLVideoElement>(null);
const bojaVideoRef = useRef<HTMLVideoElement>(null);
const ciscenjeVideoRef = useRef<HTMLVideoElement>(null);
const ricovanjeVideoRef = useRef<HTMLVideoElement>(null);
```

In addition, four more video tags are defined, one for each animation. The displayed portion of the code also includes a div tag containing buttons necessary for starting the animations. When each button is clicked, the *playVideo* function is called, which receives the name of the animation to be played as a parameter. Upon the completion of each animation, the *endVideo* function is invoked, setting the state so that no animation is active, shown in Table 1.

```
const endVideo = () => {
  setVideo('');
 }
 return (
  <div className='container'>
   <div className='image'>
    <video ref={initialVideoRef} controls={false}>
     <source src='./videos/Stampa-1.m4v'
type='video/mp4' />
    </video>
    <div className='button-container'>
     <button onClick={() =>
playVideo('boja')}>Ink</button>
     <button onClick={() =>
playVideo('stampa')}>Printing</button>
     <button onClick={() =>
playVideo('ricovanje')}>Die-cutting</button>
     <button onClick={() =>
playVideo('ciscenje')}>Cleaning</button>
    </div>
   </div>
   <video ref={stampaVideoRef}
onEnded={endVideo} controls={false}
className={'video ' + (video === 'stampa' ? 'show' :
'hide')}>
     <source src='./videos/Stampa-1.m4v'
type='video/mp4' />
    </video>
    <video ref={bojaVideoRef} onEnded={endVideo}
controls={false} className={'video ' + (video ===
'boja' ? 'show' : 'hide')}>
     <source src='./videos/Boja-1.m4v'
type='video/mp4' />
    </video>
    <video ref={ciscenjeVideoRef}
onEnded={endVideo} controls={false}
className={'video ' + (video === 'ciscenje' ? 'show' :
'hide')}>
     <source src='./videos/Ciscenje-1.m4v'
type='video/mp4' />
    </video>
    <video ref={ricovanjeVideoRef}
onEnded={endVideo} controls={false}
className={'video ' + (video === 'ricovanje' ? 'show' :
'hide')}>
     <source src='./videos/Ricovanje 1-1.m4v'
type='video/mp4' />
    </video>
   </div>
  );
}
```

Table 1

Display of the animation code

The previous steps create an interactive web application that can be run locally or on a publicly hosted website with a domain. When the application is launched, the initial screen displays either the first or last frame of the animation. Above the machine, buttons are indicating which animations can be started, and clicking on a button triggers the desired animation. This allows each video to be played unlimited times, making them appear as a cohesive unit within the application. Application can be seen in Figure 1.

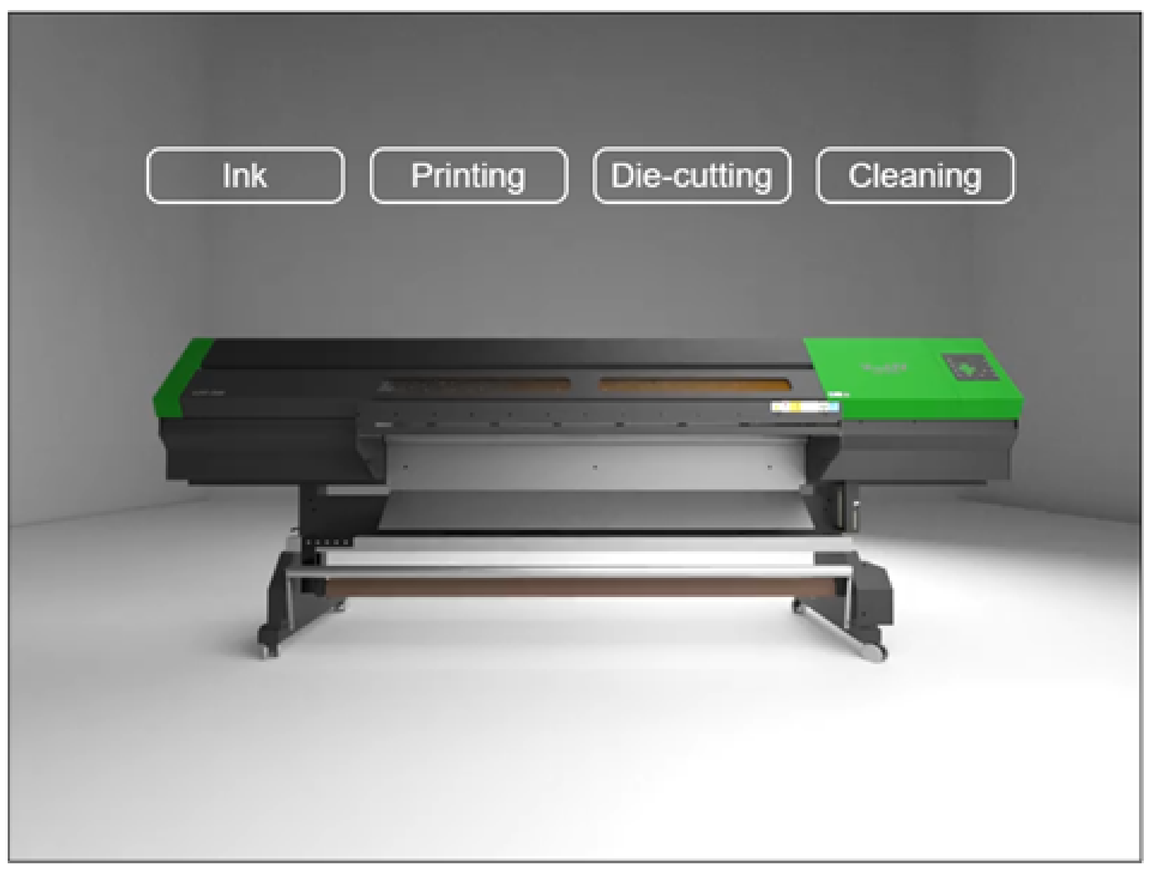

Figure 1

Initial frame of the interactive web application

Discussion / Conclusion

Through these animations, users are enabled to acquire a clear insight into how different components and processes work together. This enhances users' comprehension and knowledge and contributes to improved training and preparation for working with complex technologies. Moreover, animation enriches the learning process and opens new avenues for exploration and innovation.
This application, as defined, allows for online deployment without requiring installation on personal computers. The number of visitors is limited only by server capabilities, enabling unrestricted use in educational settings and as a supplementary resource for home learning. Future work will include optimization for mobile platforms, which are expected to become the preferred mode of learning over traditional computers among younger users.

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