

VR Lab

Lubomír Kurčák*, Erik Paľa*, Patrik Tománek*, Viktor Beňo*

Slovak university of technology in Bratislava, Faculty of Informatics and Informative Technologies, Ilkovičova 2, SK-842 16 Bratislava 4
tp16.radiant@gmail.com

1 Introduction

Because of the current coronavirus events the education system has become fragile. Mainly children are not able to go to their classrooms and continue to educate themselves, which is the most crucial part of childhood. Coronavirus pandemic has shown the world, that we are not able to educate children in the form of online teaching [1]. Especially practical exercises are completely left out because children need to attend specialized laboratories with the presence of professional supervisor [2]. We aim to overcome these coronavirus limitations by creating an online form of teaching in Virtual Reality. Our goal is to create a specialized laboratory for practical exercises in the field of electrical circuits. In this laboratory, students will be able to construct and simulate their own electrical circuits and teachers will be able to share their presentations on an interactive in-game board. We have also decided to create a lecture about constructing simple electrical circuits for an electrical go-kart, which will also be provided for all the participants. They will be able to construct various electrical circuits and put them on their go-karts. After that they can go and test their skills in electrical circuits and driving in a fun race competition with other students.

2 Related works

The authors of *Perspective Electrical Circuit Simulation with Virtual Reality* [3] created a simple 3D room as their environment for electrical circuit simulations. During the evaluation of their work, they concluded that virtual reality was determined to be the highest effective media for studying electrical circuits. In another project called *Primary School STEM Education: Using 3D Computer-based Virtual Reality and Experimental Laboratory Simulation in a Physics Case Study* [4], authors used an educational application *Water Cycle in Nature*, that focuses on physics phenomena such as vaporization and condensation. During their evaluation, they found out that 90% of participants would like to take part in more lessons, because the application eased the understanding of the described concepts.

* Master study programme in field: Informatics
Supervisor: Ing. Juraj Vincúr, Information Systems and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

3 Schooling from home

Current coronavirus pandemic disrupted the way of education around the world. The younger generation has suffered the most, because teachers, parents and students were not prepared for the drastic transition into an online education. The most vulnerable, and at the same time one of the most important fields of education are practical exercises. Practical exercises require special equipment and professional supervisor, and thus the physical presence of several persons in specialized laboratories. Because of this, an enormous number of children are not being educated properly, which will result in a serious problem in the future. That is why we have decided to overcome these coronavirus limitations and use the most modern and affordable technologies in the field of Virtual Reality, hereinafter referred as VR, to provide an online form of educating children. Thanks to the infinite opportunities of VR, we aim to create an experience, which is at least as good and effective as teaching from inside of a specialized school laboratory [5].

As our main goal, we have decided to create an online laboratory for practical exercises in the field of electrical circuits. Users will be located in specialized laboratory, in which every user will have their own working space. This working space will consist of a grid-board and a set of electrical components, which can be inserted into the mentioned grid-board. After constructing their electrical circuits, users will be able to test their functionality through a real-time simulation of this circuit.

Our project will consist of two ways of teaching. The first way is teaching with a teacher, and the second one is teaching without a teacher. Both ways will be described herein.

3.1 Teaching with a teacher

Teachers and their students will be able to join their own dedicated online laboratory. Every participant will obtain their own working space. As for teachers, they will also obtain a fully interactive board. On this board they will be able to share their own presentations from their devices, highlight important parts of the presentation or draw whatever they need.

3.2 Teaching without a teacher

It's important for us to create an opportunity of education to every user that has the desire to learn. We have decided to create one lecture, in which we will provide information and tutorial on how to build electrical circuits for a simple electrical go-kart. Users will be able to understand and create such circuits without a need for a teacher.

With the opportunity of creating a VR game, we think that it is important to provide quality education with something extra. That is why we have decided to provide a simple electric go-kart 3D model to every participant in this lecture. After finishing the education part of the lecture, they will be able to test the functionality of their circuits in a fun race. Prior to that, they will first need to put all their electrical circuits on the

go-kart. During the lecture, they will be able to create various electrical circuits such as simple electric motor, lights, horn, and so on. With every correctly build circuit their go-kart will be upgraded.

When their go-kart meets the minimal requirements to join the race, all the participants will be situated on a pre-created race map. At this race they will be able to compare their skills in electrical circuits as well as driving. We believe that this way of education, with something extra, will be even better and more effective as teaching from inside of a specialized laboratory with no fun parts involved during the process.

4 Current results

The current state of the project consists of the following parts:

- Interactive working station – the working station consists of 3 main parts:
 - Gridboard part allows users to construct their own electrical circuits on a futuristic table. All connections are displayed on a standalone console screen. Each gridboard table also has its own terminal, from which users can operate this simulation. Users can start simulation, remove all components from gridboard table, generate spice code of currently simulated electrical circuit or change components values during the simulation. See Figure 1 for visual details.
 - Component modifier part allows users to pick up all of the available electrical components, as well as create their own specifications. Users are able to pick up a component and put it into the tuning station. From this station users can permanently change component values, as well as models. They can create and insert their own model specification using spice language statements. After that the terminal will parse this specification and create a new available model, which can be used on given component. Players can also save all of their modified components, so they won't have to create them again in the future. See Figure 2 for visual details.
 - Vehicle part allows users to see the current progress of their go-kart. Go-kart parts as motor, lights, horn, etc. will need their own electrical circuit to be functioning. Players have to build these circuits and insert them into the given parts. These parts then can be inserted back to the go-kart. After their go-kart is finished, they can take it for a drive.
- Integration of Spice# [6] and Spice#Parser [7] projects for electrical circuits simulation – the process of creating electrical circuits in-game and running simulation is described in Figure 3. For this simulation to be running in real time without affecting the performance of our game, it is mandatory to establish standalone thread for Spice# calculations. Every working station can only have one running simulation at a time. The process of creating this instance is described in Figure 4.

- Integration of go-kart physics – the player is able to sit in his go-kart and take it for a drive. This go-kart has a fully interactive steering wheel as well as a lever, with which the player can change speed of the go-kart.
- Interactive board – player is able to write whatever he needs on an interactive board. Player is also presented with several differently colored marker pens.



Figure 1 - Gridboard station



Figure 2 - Tuning station

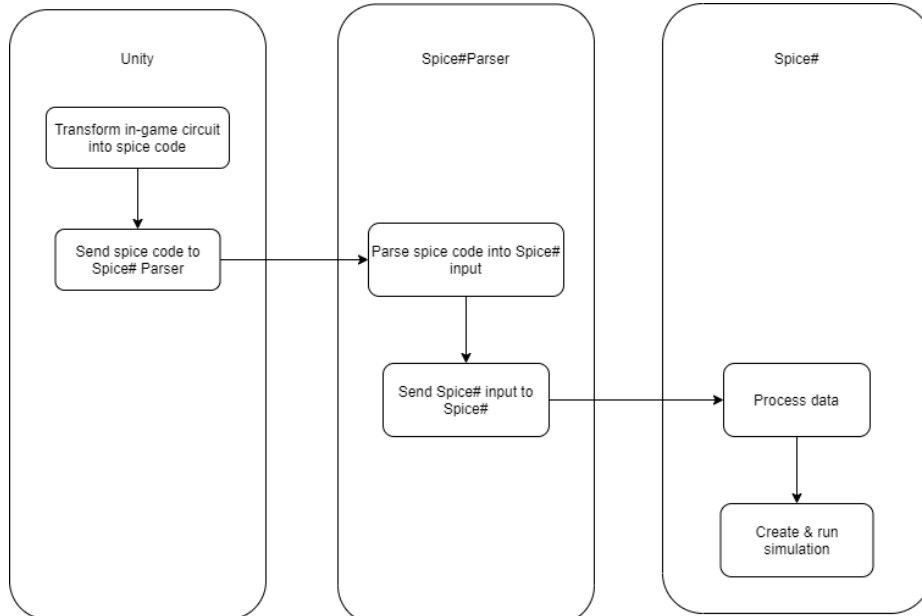


Figure 3 - Process of running simulation

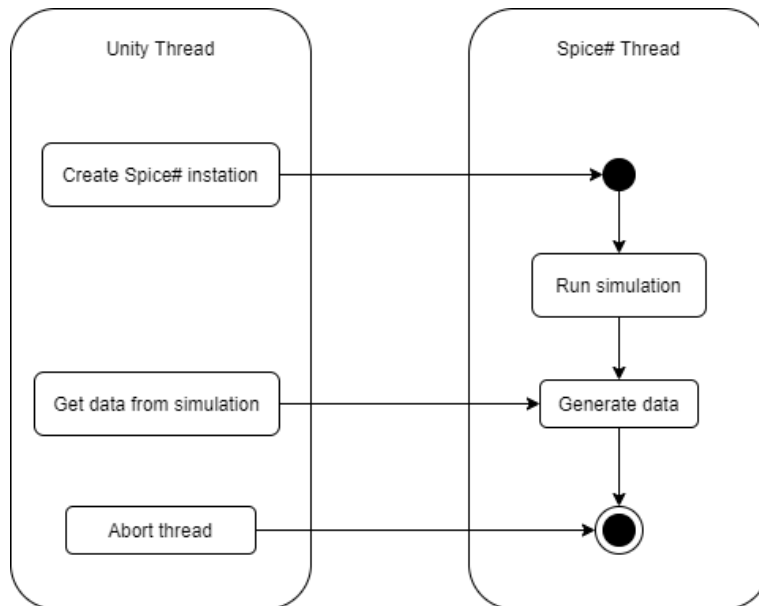


Figure 4 - Creating Spice# instance

5 Technologies used

In our project we work with several technologies:

1. Unity – game engine
2. VR Interaction Framework – collection of scripts and prefabs that aim to help with development of interactions in VR
3. Spice# - spice-based circuit simulator
4. Spice#Parser – parses spice netlists and simulates them using Spice#

6 Future work

- Currently our prototype only supports one client who controls the application from his local machine. One important aspect of future development is support for multiplayer collaboration for designing and creating the vehicle and its circuits.
- For now, we do not have the means to test our work with real participants. Testing would help us make improvements regarding our teaching material or help us solve some technical problems that could arise during the teaching process.
- We would also like to implement more functionalities for our go-kart model that could provide additional electrical components as learning material. With this comes the need for new electric component models and some new animations. Another aspect to consider is VR headset performance optimization for smooth experience.

7 Conclusion

In response to the current international pandemic, we propose an alternative solution to provide practical education and hands-on experience that substitutes physical in-person experience. We have demonstrated the plausibility of our approach with the aim to mimic the interactivity of real-world laboratory work leveraging virtual reality, while keeping the students and teachers physically distanced and protected. We believe virtual reality has applications in education as it makes experiments safer, more accessible and without the need for any physical resources other than the headset itself.

References

1. NICOLA, Maria, et al. The socio-economic implications of the coronavirus and COVID-19 pandemic: a review. *International journal of surgery*, 2020.
2. BOGUSEVSCHI, Diana; MUNTEAN, Cristina; MUNTEAN, Gabriel-Miro. Teaching and learning physics using 3D virtual learning environment: A case study of combined virtual reality and virtual laboratory in secondary school. *Journal of Computers in Mathematics and Science Teaching*, 2020, 39.1: 5-18.

3. NUANMEESRI, Sumitra; POOMHIRAN, Lap. Perspective Electrical Circuit Simulation with Virtual Reality. *International Journal of Online & Biomedical Engineering*, 2019, 15.5.
4. BOGUSEVSCHI, Diana, et al. Primary school STEM education: using 3D computer-based virtual reality and experimental laboratory simulation in a physics case study. In: Ireland International Conference on Education, IPeTEL workshop, Dublin. 2018.
5. CALVERT, James; ABADIA, Rhodora. Impact of immersing university and high school students in educational linear narratives using virtual reality technology. *Computers & Education*, 2020, 159: 104005.
6. Sven Boulanger, SpiceSharp, 2017.
<https://github.com/SpiceSharp/SpiceSharp>
7. Marcin Golebiowski, SpiceSharpParser, 2018.
<https://github.com/SpiceSharp/SpiceSharpParser>