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VisualComputing MAGAZiNE

N°1/ 2023

Tiny Machine Learning

In the practical work of ML&NN course of Visual Computing Master, USTHB

In this Month

One of the first Holders of a master's degree in visual computing

Gesture recognition with Arduino Nano 33 BLE Sense

Presented at TINYML4D workshop, January 2023

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Visual Computing Magazine

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The preface

Dear Readers,
It is my pleasure to introduce the inaugural issue of the New Magazine of Visual Computing. This magazine is dedicated to showcasing the latest scientific research and development in the field of visual computing, with a particular focus on the work of master's and PhD students, as well as researchers.

Visual computing is a field that combines computer science, mathematics, and engineering to create and analyze visual content, such as images, videos, and animations. The field is rapidly advancing, and the New Magazine of Visual Computing aims to provide a platform for the dissemination of cutting-edge works and recent research in this exciting area.

Our goal is to bring together researchers, practitioners, and students to exchange ideas and share their latest findings, while also providing a forum for discussion and collaboration. We believe that by highlighting the work of talented students and researchers, we can foster innovation and contribute to the growth of visual computing as a field.

In this first issue, you will find a range of articles covering a variety of topics in visual computing, including computer vision, data visualization, Machine learning and human-computer interaction. We hope that you will find these articles informative and thought-provoking, and that they will inspire new ideas and directions for future research.

Finally, I would like to express my gratitude to the Master and PhD students and their supervisors who have contributed to this issue. We look forward to your feedback and suggestions, as we strive to make the New Magazine of Visual Computing a valuable resource for the scientific community.
Sincerely,

Prof. Slimane LARABI

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Human Computer Interaction: Hand Gesture recognition Using Tiny Machine Learning

Koulal Yidhir Aghiles, Labchri Amayas, Bourzam Saad Allah, Baroud Yasmine and Bourbia Amine. Visual Master Sutdents, USTHB

Introduction

The traditional input methods such as keyboard, mouse, and controllers, have limitations in terms of flexibility and intuitiveness, which may not cater to all users. This project aims to overcome these limitations by proposing a more natural and intuitive way of interacting with electronic devices. Recognizing hand gestures is a promising approach as it allows users to interact with the devices in a way that mimics their natural body language.

This project utilizes two "***Arduino Nano 33 BLE Sense***" devices to recognize hand gestures and translate them into game controls, which would enable users to perform actions such as jumping, moving left or right, shooting, protecting, and adjusting speed by making hand gestures.

The proposed solution has the potential to enhance user experience, especially in interactive environments such as gaming or smart homes, where intuitive and natural interaction is highly desirable.

The Arduino Nano 33 BLE Sense

Data collection:

In order to train the machine learning model for hand gesture recognition, data collection plays a crucial role. The data collection process involves recording multiple repetitions of each gesture. In this project, four basic gestures are considered: **up**, **down**, **right**, and **left**.

During the data collection process, each repetition of a gesture generates 119 samples, which include 3 values of acceleration (aX, aY, aZ) and 3 values of gyroscope (gX, gY, gZ). These values are recorded from the sensors on the "Arduino Nano 33 BLE Sense" devices, which capture the hand movements associated with each gesture. The combination of acceleration and gyroscope values provides a detailed representation of the hand gesture, which is crucial for accurate recognition.

The collected samples are then saved in a CSV file, which is used in the training process of the machine learning model.

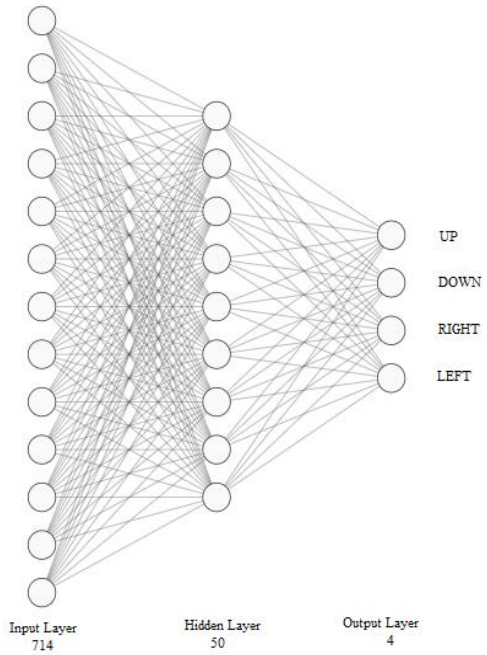
Arduino Nano Arduino held by hand for data acquisition

Human Computer Interaction: Hand Gesture recognition Using Tiny Machine Learning

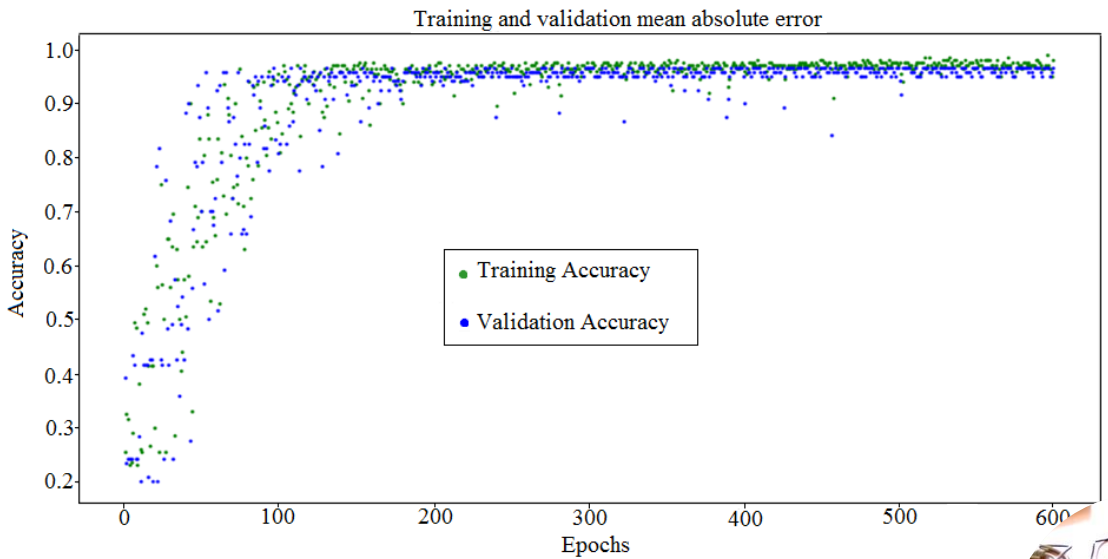
Machine learning model architecture:

The machine learning model architecture utilized in this project includes an input layer with 714 nodes, a hidden layer with 50 nodes, and an output layer with four nodes representing the movements: Up, Down, Right, and Left. The input layer receives 714 samples, generated during the data collection process, consisting of acceleration and gyroscope values for each gesture (119*6=714). The output layer is responsible for classifying each gesture based on its corresponding movement.

During the training process of the machine learning model, 100 samples are used for each gesture. This ensures that the model is trained with a sufficient amount of data for each gesture, enabling it to recognize and classify hand movements with greater accuracy.
It is also important to note that the model is trained using 600 iterations. This allows it to fine-tune its predictive capabilities over time and make accurate predictions even in complex and dynamic scenarios where hand gestures may vary in speed or trajectory.



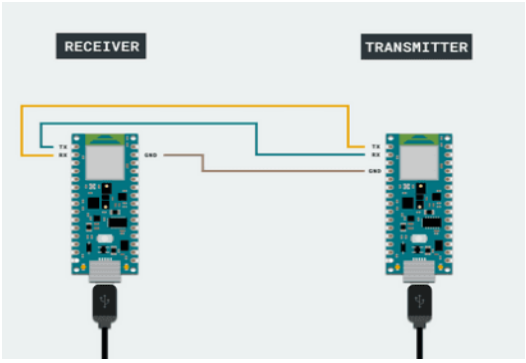
The used Shallow Neural Network



Human Computer Interaction: Hand Gesture recognition Using Tiny Machine Learning

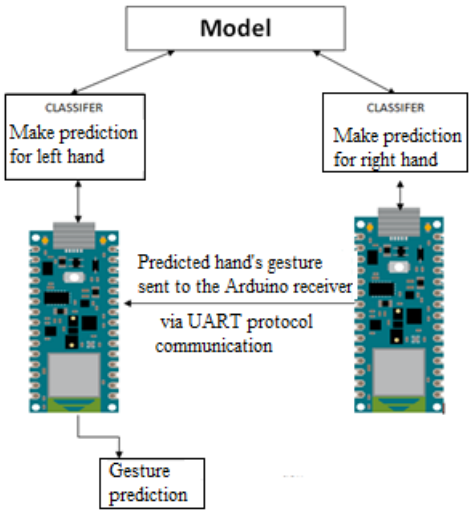
Communication protocol

Accurate recognition of hand gestures requires the communication between the two "Arduino Nano 33 BLE Sense" devices. To achieve this, the project uses the Universal Asynchronous Receiver-Transmitter (UART) communication protocol. This protocol enables the transmission of data between the devices asynchronously, allowing for configurable data format and transmission speed.
Specifically, when the right-hand Arduino device makes a prediction, it sends this information to the left-hand receiver Arduino using the UART communication protocol. This process ensures that both devices are synchronized and work together to accurately predict the final gesture.



Hand gesture recognition and classification process

The process involves using a trained machine learning model to classify hand gestures on individual Arduino devices.
This enables each device to independently predict hand gestures for the right and left hand.
Once the right-hand Arduino makes a prediction, it transmits the prediction to the left-hand Arduino using the UART communication protocol. The left-hand Arduino then combines the predictions from both hands to accurately predict the final gesture.
Using a machine learning model facilitates accurate and efficient recognition of hand gestures. Furthermore, the seamless communication protocol between the Arduinos enhances the user experience.



Geospatial Visualization of Computer Science Faculty Activities at USTHB Campus

Bourzam Saad Allah, Baroud Yasmine . Visual Master Sutdents, USTHB

The aim of this project is to visualize the activities of the Computer Science Faculty on the USTHB campus by creating an interactive map of the university. This map will display information about the utilization of various rooms and facilities by computer science students.
With this project, users will be able to interactively explore the activities of the Computer Science Faculty on the USTHB campus. They can view room occupancy, instructor schedules, and events at various times and dates, providing a valuable resource for students, staff, and administrators to plan their activities effectively.

The visualization shows the occupancy for a specific time slot during a given day and semester(classes colored by blue color).

Implementation Steps

1. Create a map of the USTHB campus, including the rooms used by the Computer Science Faculty such as computer labs, lecture rooms, amphitheaters, meeting rooms, etc. This by creating a new GeoJSON file and a mapping tool (https://geojson.io) to draw boundaries for different areas.
2. Collect data on the room occupancy, subjects, group numbers, and instructors for computer science student's specialization. This by creating python script that extracts all relevant information from PDF schedule files.
3. Visualize the room occupancy by Master's students in the Visual Computing specialization on the map and computer science student's (level L2 to M2). The visualization shows the occupancy for a specific time slot during a given day and semester. The display includes information about the subject being taught, room number, group or section number, and the instructor's name using a tooltip data visualization type.
4. Add the ability to visualize the schedule time and rooms used by a specific instructor.

Geospatial Visualization of Computer Science Faculty Activities at USTHB Campus

Approach:

- Implement an interactive map using a suitable JavaScript library D3.js to display the campus layout and class occupancy information.
- Add filters and controls to the map interface to allow users to select specific time slots, days, and semesters.
- Add a zoom function to zoom the map.
- Integrate event data and display it on the map to visualize ongoing or planned events.

Results:

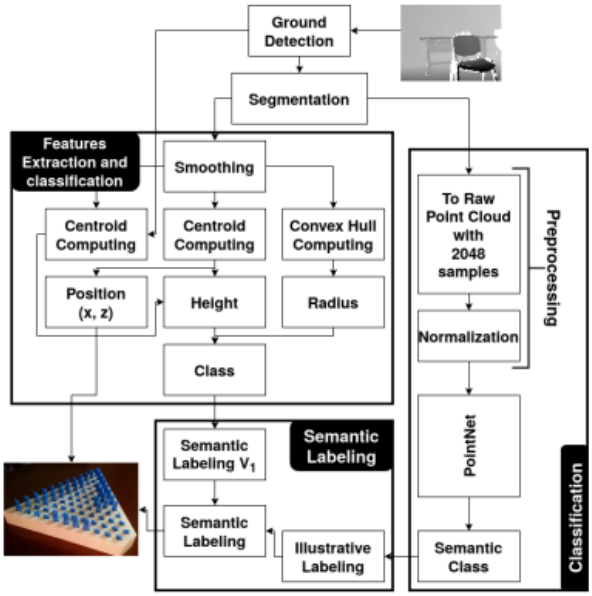
The visualization shows information about the subject being taught, class number, group or section number, and the instructor's name using a tooltip for a specific class.

A tactile device for Scene understanding

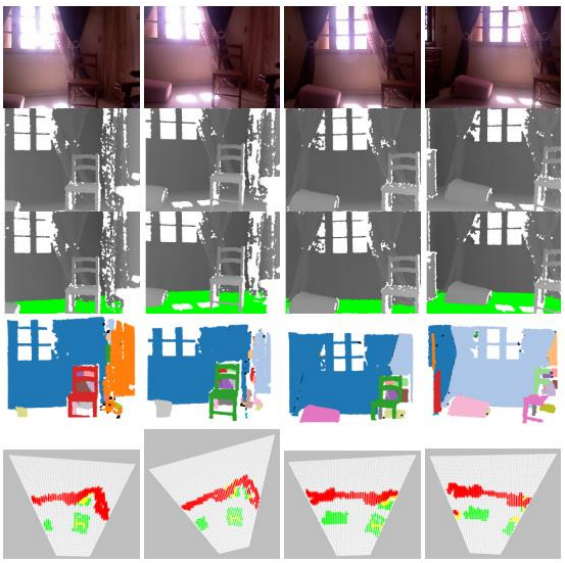
Chayma Zatout. PhD , Supervisor: Prof. Slimane LARABI, USTHB

Introduction

In daily life, people continuously interact with their surroundings in various ways, such as sitting on a chair, walking on a sidewalk, and navigating. To accomplish these tasks, humans execute a set of actions: first, they acquire information about the scene they are in, then they understand it and act accordingly. While obvious, it is important to state that understanding a scene is a fundamental step before executing most tasks, and it involves retrieving the scene geometry, detecting and locating objects, and identifying their shapes and relationships.



System overview



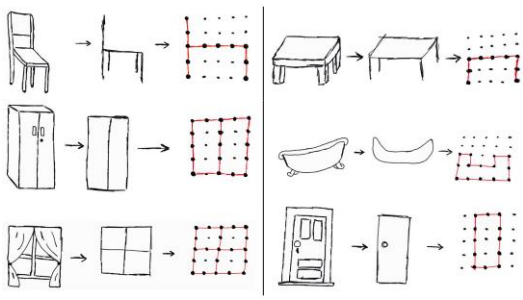
The execution of the system's different steps.

The method

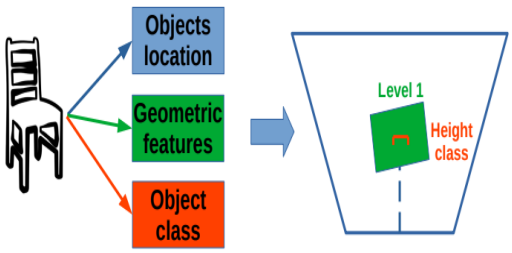
My thesis, entitled "Semantic Scene Labeling using RGB-D Data for Human-Scene Interaction", focuses on automating scene understanding, also known as scene semantic labeling. The main aim of my thesis is to build a computer-based system that can understand scenes for human-scene interaction using RGB-D data. The proposed system is based on point cloud processing computed from RGB-D data and includes four main steps. Firstly, the system detects the ground and extracts the occupied space that represents the objects in the captured scene.

A tactile device for Scene understanding

Secondly, the 3D representation of the occupied space is segmented using a clustering algorithm to extract the different objects constructing the scene. Thirdly, each object is classified using a deep neural network, and other object characteristics are extracted directly from the object's point cloud representation. Finally, the computed classes and features are used to generate semantic labels, providing a comprehensive understanding of the scene.



Semantic labels.



Mapping principle.

The results

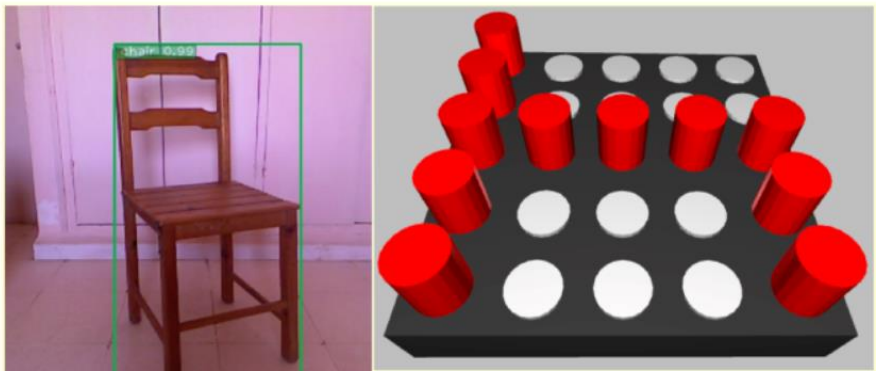
You may be wondering why we need to build a system to understand scenes when humans can do it effortlessly. The fact is that scene understanding is a critical component of many systems, particularly aids systems for people with visual impairments. In my thesis, the second and main focus was on developing a visually impaired aid system that uses semantic labels generated from scene understanding. As mentioned earlier, the system generates semantic labels that provide a comprehensive description of the scene. These labels are mapped onto a device called BASISR, which is designed to be understood by touch. The use of touch as a mode of understanding as well the deisgn of BASISR can be the subject of a whole article, but for now, we will only touch on the topic briefly. The semantic labels we propose are inspired by the Braille system and Kanji, the Japanese writing system. They are derived from the objects' shapes in the real world and represented in cells with 25 raised dots.

Once the geometric features and classes of the objects in the scene are computed, we generate their semantic labels on the BASISR device at the objects' locations. To represent the object's shape, the convex hull of the segment is mapped. To represent the object's class, the corresponding label is mapped onto the center. To represent the object's height, the label height corresponds to the object's actual height. By exploring the BASISR surface, visually impaired individuals can understand the objects' locations in the scene, their nature, and their height. This information can be used to accomplish various tasks such as navigation and searching for objects.

A tactile device for Scene understanding

Conclusion

This article has provided a brief overview of the focus of my thesis, which aims to develop a system for semantic scene labeling using RGB-D data for human-scene interaction, with a particular emphasis on developing a visually impaired aid system. The development of such a system holds great promise for improving the quality of life of individuals with visual impairments and underscores the importance of scene understanding in a variety of applications.



Left: The recognized object, Right: Its coding on synthetized 5x5 pins

The prototype of the Device designed and realized by the Master Students on Electronic of Embedded Systems at USTHB University: BOUCHTOUT Khadidja and SAADAT Nadia

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April 2023

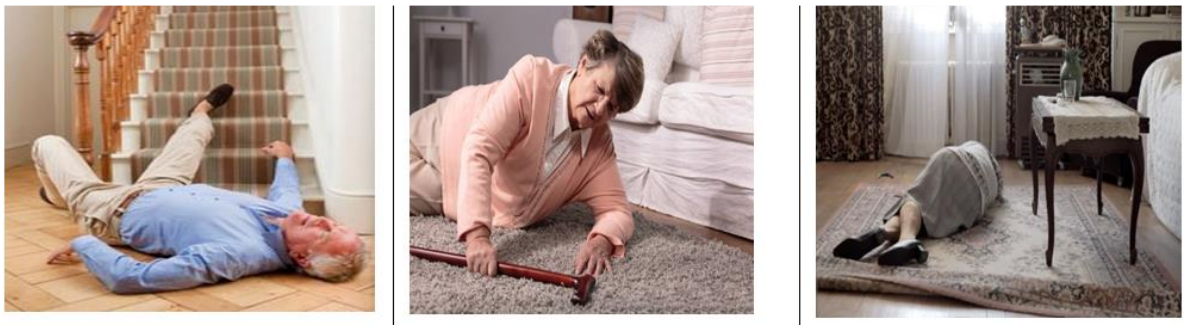
Falls detection and prediction of an elderly person in an indoor environment using a vision system

Fairouz MERROUCHE. PhD Sutdent, USTHB, **Supervisor**: Prof. Nadia BAHA, USTHB

Introduction

The world's population is aging, living independently and without risks for the elderly is a major challenge for a system of human activity recognition. The fall of an elderly person can be fatal or can lead to health problems and a loss of their autonomy.

The main objective of this work is to propose a monitoring system based on the computer vision and human activity recognition to detect the fall, or even predict it in the future to improve performance and assistance time to the person, which can avoid staying on the ground hours before help arrives. This solution is based on a single Kinect sensor to monitor the elderly person.



Example of an elderly person fall

The method and Results

Two fall detection methods are proposed: the first method is based on the human form and the movement of the center of gravity. The first step consists in the detection of the person in the image using background subtraction methods, then his head is tracked using the particle filter. Three scenarios were tested. For the first and second scenarios, head position is used to detect postures that are close to the ground. The movement of the center of gravity is analyzed to validate the falls. Regarding the third scenario, the person's tilt angle is calculated to detect abnormal postures. To validate the fall, we used the center of gravity movement as for the other two scenarios.

In the second method, the HOG descriptor and Hu moments were used to describe human posture by incorporating center of gravity motion to describe human activity. We also proposed a new descriptor that we called HDO. This descriptor is based on the orientation of each contour point of the silhouette as well as the distances of these points from the center of gravity. Several classification methods have been used to differentiate a fall from normal activity.

Falls detection and prediction of an elderly person in an indoor environment using a vision system

The third part was devoted to fall prediction, we used Transfer Learning based on CNN architecture to detect imbalance of the human body. To discriminate falls from normal activities, we analyzed the center of gravity velocity for k frames where k is less than the duration of a fall. Very good results have been obtained for the detection and prediction of falls on the tests conducted on the SDU and URFall databases.

Example examples of Fall Detection with the SDU Fall Dataset

Example examples of Fall Detection with the URFall *Dataset*

One of the first Holder sof a master's degree in visual computing, USTHB

Mounsif Chetitah

In 2015, I had the privilege of taking part in the first Master of Visual Computing class, where I gained extensive knowledge and expertise in various aspects of visual computing methodologies and technologies. The program covered topics such as computer vision, virtual reality, data visualization, games, and creative design. As part of my master's thesis, I developed an interactive web application that utilized data visualization techniques to guide the user through campus activities.

After completing my studies, I worked at GeoSystem, a company specializing in geographical information systems, where I developed my knowledge of software such as ArcGIS and QGis. During my tenure, I worked on several projects, including one for the Ministry of Culture that involved the inventory of geographical elements in the M'Zab valley. Additionally, I worked on various other projects such as a collaboration tool for the Ministry of Environment, which gave me experience handling complex data sets.

One year later, I decided to pursue a master's degree in Image and Sound for Intelligent Systems at Sorbonne University in Paris, France. In this program, I developed a proof-of-concept application that was later published as a full paper in the IEEE Cognitive and Informatics Conference in 2020.

Since completing my studies, I have participated in several exhibitions on VR and AR technologies in Algiers and Oran. In April 2020, I began my PhD studies at the University of Würzburg in Germany (Human-Computer Interaction chair, Games Engineering group), with a primary focus on developing a framework for serious game design and development. My research involves the study of interactive simulations, game technologies, game design, learning theories and pedagogy, and artificial intelligence. Additionally, I teach game engine technologies, asset development and 3D modeling, as part of my work. Over the past three years, I have supervised several bachelor and master students, proposed seminar topics, and collaborated with various professionals, including neuropsychologists, artists, and architects, to design and develop interactive simulations to solve complex problems.

My passion lies in using technology to solve complex problems and make a positive impact on society. If you're interested in my work or would like to explore future collaborations, please reach out to me on LinkedIn (Mounsif Chetitah) or by email (mounsif.chetitah@gmail.com).

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