

# T e k h n ê

**Tecnología al servicio de la sociedad**

Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

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- Superior derecha: Input vs. output plot for Sigmoid activation function (Rodríguez, A., and Buitrago, X.)
- Centro: How to choose an activation function for the output layer (Rodríguez, A., and Buitrago, X.)
- Inferior izquierda: Screenshots of the video under analysis (Rendón, A.)
- Inferior derecha: Speeds vm1 and vm2 along the time (Rendón, A.)

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## Revista Tekhnê

La revista **Tekhnê** es una publicación institucional de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas. Posee un carácter científico, y atiende a la comunidad nacional e internacional especialista en áreas de ingenierías eléctrica, electrónica, mecánica, de sistemas, industrial y civil. Publica resultados de investigación en inglés (artículos originales e inéditos), y está completamente abierta a especialistas de todo el mundo en calidad de autores y/o lectores. Es arbitrada mediante un proceso doble ciego, con rotación continua de árbitros. La periodicidad de la conformación de sus comités Científico y Editorial está sujeta a la publicación de artículos en revistas indexadas internacionalmente por parte de sus respectivos miembros.

## Periodicidad

La revista **Tekhnê** posee una periodicidad semestral, coincidente con los semestres académicos de la Universidad Distrital. La publicación se realiza los meses de julio y diciembre. El primer volumen de la revista se publicó el primer semestre de 2003, manteniendo su regularidad hasta la fecha.

## Misión

La revista **Tekhnê** tiene como misión divulgar resultados de investigación realizados en el área de la ingeniería, a través de la publicación de artículos originales e inéditos, realizados por académicos y profesionales pertenecientes a instituciones nacionales o extranjeras del orden público o privado. Propende por la difusión de resultados y su acceso abierto y libre.

## Público objetivo

La revista está dirigida a docentes, investigadores, estudiantes y profesionales interesados en la actualización permanente de sus conocimientos y el seguimiento de los procesos de investigación científica en el campo de la ingeniería.

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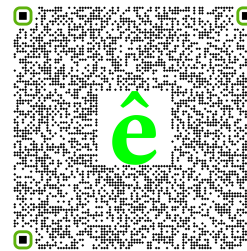
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## **Tekhnê Journal**

**Tekhnê** journal is an institutional publication of the Facultad Tecnológica of the Universidad Distrital Francisco José de Caldas (Bogotá D.C. - Colombia). It has a scientific character and serves the national and international community specialized in the areas of electrical, electronic, mechanical, systems, industrial and civil engineering. It publishes research results in English (original and unpublished articles), and is completely open to specialists from around the world as authors and/or readers. It is arbitrated through a double-blind process, with continuous rotation of arbitrators. The periodicity of the formation of its Scientific and Editorial Committees is subject to the publication of articles in internationally indexed journals by their respective members.

## **Periodicity**

**Tekhnê** journal is published every six months, coinciding with the academic semesters of the Universidad Distrital. It is published in July and December. The first volume of the journal was published in the first semester of 2003, maintaining its regularity to date.

## **Mission**

The mission of **Tekhnê** journal is to disseminate research results conducted in the area of engineering, through the publication of original and unpublished articles by academics and professionals belonging to national or foreign institutions of public or private order. It aims at the diffusion of results and their open and free access.

## **Target audience**

The journal is aimed at professors, researchers, students, and professionals interested in permanently updating their knowledge and monitoring scientific research processes in the field of engineering.

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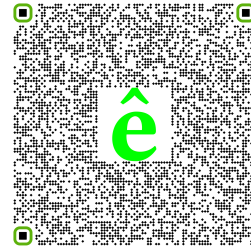
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# Declaración de ética y buenas prácticas

## Tekhnê

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Revista Tekhnê  
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El comité editorial de la revista **Tekhnê** está comprometido con altos estándares de ética y buenas prácticas en la difusión y transferencia del conocimiento, para garantizar el rigor y la calidad científica. Es por ello que ha adoptado como referencia el Código de Conducta que, para editores de revistas científicas, ha establecido el Comité de Ética de Publicaciones (COPE: Committee on Publication Ethics) dentro de los cuales se destaca:

### Obligaciones y responsabilidades generales del equipo editorial

En su calidad de máximos responsables de la revista, el comité y el equipo editorial de **Tekhnê** se comprometen a:

- Aunar esfuerzos para satisfacer las necesidades de los lectores y autores.
- Propender por el mejoramiento continuo de la revista.
- Asegurar la calidad del material que se publica.
- Velar por la libertad de expresión.
- Mantener la integridad académica de su contenido.
- Impedir que intereses comerciales comprometan los criterios intelectuales.
- Publicar correcciones, aclaraciones, retractaciones y disculpas cuando sea necesario.

### Relaciones con los lectores

Los lectores estarán informados acerca de quién ha financiado la investigación y sobre su papel en la investigación.

### Relaciones con los autores

**Tekhnê** se compromete a asegurar la calidad del material que publica, informando sobre los objetivos y normas de la revista. Las decisiones de los editores para aceptar o rechazar un documento para su publicación se basan únicamente en la relevancia del trabajo, su originalidad y la pertinencia del estudio con relación a la línea editorial de la revista.

La revista incluye una descripción de los procesos seguidos en la evaluación por pares de cada trabajo recibido. Cuenta con una guía de autores en la que se presenta esta información. Dicha guía se actualiza regularmente y contiene un vínculo a la presente declaración ética. Se reconoce el derecho de los autores a apelar las decisiones editoriales.

Los editores no modificarán su decisión en la aceptación de envíos, a menos que se detecten irregularidades o situaciones extraordinarias. Cualquier cambio en los miembros del equipo editorial no afectará las decisiones ya tomadas, salvo casos excepcionales en los que confluían graves circunstancias.

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**Tekhnê** pone a disposición de los evaluadores una guía acerca de lo que se espera de ellos. La identidad de los evaluadores se encuentra en todo momento protegida, garantizando su anonimato.

### Proceso de evaluación por pares

**Tekhnê** garantiza que el material remitido para su publicación será considerado como materia reservada y confidencial mientras que se evalúa (doble ciego).

### Reclamaciones

**Tekhnê** se compromete responder con rapidez a las quejas recibidas y a velar para que los demandantes insatisfechos puedan tramitar todas sus quejas. En cualquier caso, si los interesados no consiguen satisfacer sus reclamaciones, se considera que están en su derecho de elevar sus protestas a otras instancias.

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**Tekhnê** asume su obligación para actuar en consecuencia en caso de sospecha de malas prácticas o conductas inadecuadas. Esta obligación se extiende tanto a los documentos publicados como a los no publicados. Los editores no sólo rechazarán los manuscritos que planteen dudas sobre una posible mala conducta, sino que se consideran éticamente obligados a denunciar los supuestos casos de mala conducta. Desde la revista se realizarán todos los esfuerzos razonables para asegurar que los trabajos sometidos a evaluación sean rigurosos y éticamente adecuados.

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Cada vez que se tenga constancia de que algún trabajo publicado contiene inexactitudes importantes, declaraciones engañosas o distorsionadas, debe ser corregido de forma inmediata.

En caso de detectarse algún trabajo cuyo contenido sea fraudulento, será retirado tan pronto como se conozca, informando inmediatamente tanto a los lectores como a los sistemas de indexación.

Se consideran prácticas inadmisibles, y como tal se denunciarán las siguientes: el envío simultáneo de un mismo trabajo a varias revistas, la publicación duplicada o con cambios irrelevantes o parafraseo del mismo trabajo, o la fragmentación artificial de un trabajo en varios artículos.

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**Tekhnê** establecerá los mecanismos necesarios para evitar o resolver los posibles conflictos de intereses entre autores, evaluadores y/o el propio equipo editorial.

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Cualquier autor, lector, evaluador o editor puede remitir sus quejas a los organismos competentes.

# Code of ethics and good practice

## Tekhnê

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Facultad Tecnológica

The editorial board of **Tekhnê** journal is committed to ethics high standards and good practice for knowledge dissemination and transfer, in order to ensure rigour and scientific quality. That is why it has taken as reference the Code of Conduct, which has been established by the Committee on Publication Ethics (COPE) for scientific journal editors; outlining the following:

### General duties and responsibilities of the editorial board

As most responsible for the journal, **Tekhnê** committee and the editorial board are committed to:

- Joining efforts to meet the readers and authors needs.
- Tending to the continuous improvement of the Journal.
- Ensuring quality of published material.
- Ensuring freedom of expression.
- Maintaining the academic integrity of their content.
- Prevent commercial interests compromise intellectual standards.
- Post corrections, clarifications, retractions and apologies when necessary.

### Relations with readers

Readers will be informed about who has funded the research and their role in the research.

### Relations with authors

**Tekhnê** is committed to ensuring the quality of published

material, informing the goals and standards of the journal. The decisions of publishers to accept or reject a paper for publication are based solely on the relevance of the work, originality and pertinence of the study with journal editorial line.

The journal includes a description of the process for peer evaluation of each received work, and has an authors guide with this information. The guide is regularly updated and contains a link to this code of ethics. The journal recognizes the right of authors to appeal editorial decisions.

Publishers will not change their decision in accepting or rejecting articles, unless extraordinary circumstances or irregularities are detected. Any change in the editorial board members will not affect decisions already made, except for unusual cases where serious circumstances converge.

### Relations with evaluators

**Tekhnê** makes available to reviewers a guide to what is expected from them. Reviewers identity is protected at all times, ensuring anonymity.

### Peer review process

**Tekhnê** ensures that material submitted for publication will be considered private and confidential issue while being reviewed (double blind).

### Claims

**Tekhnê** is committed to respond quickly to complaints and ensure that dissatisfied claimant can process all complaints. In any case, if applicants fail to satisfy their claims, the journal considers that they have the right to raise their protests to other instances.

### Promoting academic integrity

**Tekhnê** ensures that the published material conforms to internationally accepted ethical standards.

### Protection of individual data

**Tekhnê** guarantees the confidentiality of individual information (e.g. participant teachers and/or students as collaborators or subjects of study in the presented research).

### Tracking malpractice

**Tekhnê** accepts the obligation to act accordingly in case of suspected malpractice or misconduct. This obligation extends both to publish and unpublished documents. The editors not only reject manuscripts with doubts about possible misconduct, but



they are considered ethically obligated to report suspected cases of misconduct. From the journal every reasonable effort is made to ensure that works submitted for evaluation are rigorous and ethically appropriate.

### **Integrity and academic rigour**

Whenever evidence that a published work contains significant misstatements, misleading or distorted statements, it must be corrected immediately.

In case of any work with fraudulent content is detected, it will be removed as soon as it is known, and immediately informing both readers and indexing systems.

Practices that are considered unacceptable and as such will be reported: simultaneous sending of the same work to various journals, duplicate publication with irrelevant changes or paraphrase of the same work, or the artificial fragmentation of a work in several articles.

### **Relations with owners and journal editors**

The relation between editors, publishers and owners will be subject to the principle of editorial independence. **Tekhnê** will ensure that articles are published based on their quality and suitability for readers, and not for an economic or political gain. In this sense, the fact that the journal is not governed by economic interests, and defends the ideal of universal and free access to knowledge, provides that independence.

### **Conflict of interest**

**Tekhnê** will establish the necessary mechanisms to avoid or resolve potential conflicts of interest between authors, reviewers and/or the editorial board itself.

### **Complaints/allegations**

Any author, reader, reviewer or editor may refer their complaints to the competent authorities.



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# Editorial

El modelo educativo colombiano ha experimentado cambios significativos en los últimos años, pasando de un modelo tradicional centrado en la memorización y la instrucción centrada en el profesor a un modelo basado en competencias que enfatiza la adquisición de habilidades y el desarrollo de capacidades de pensamiento crítico. Uno de los elementos clave de esta transición ha sido la aplicación de las Directrices Curriculares Nacionales, que esbozan las competencias que se espera que los estudiantes adquieran en cada grado. Estas competencias se organizan en cuatro categorías: cognitivas (conocimientos y comprensión), psicomotoras (destrezas y habilidades), afectivas (valores y actitudes) y comunicativas (lenguaje y comunicación).

El modelo basado en competencias pretende fomentar un enfoque más activo y autodirigido del aprendizaje, así como garantizar que los estudiantes tengan las habilidades y los conocimientos necesarios para triunfar en el siglo XXI. Para apoyar esta transición, el gobierno colombiano ha invertido en el desarrollo de nuevos planes de estudio y materiales didácticos, así como en la formación de profesores. El actual modelo de resultados de aprendizaje de Colombia se basa en los principios del modelo de educación por competencias. Se centra en la adquisición de conocimientos y el desarrollo de competencias y valores, a través de una evaluación continua y holística del estudiante. Utiliza un sistema de evaluaciones anuales, semestrales y finales, que valoran cada una de las competencias. Este sistema de evaluación establece también que las calificaciones obtenidas por los alumnos deben ser una media ponderada de las evaluaciones de las competencias.

En general, el modelo educativo colombiano está diseñado para preparar a los estudiantes para el éxito en un mundo que cambia rápidamente, fomentando el desarrollo de habilidades de pensamiento crítico, el amor por el aprendizaje y el compromiso con el compromiso cívico. El país ha hecho grandes esfuerzos en los últimos años para la transición a un modelo basado en competencias y actualmente trabaja en el desarrollo y la implementación para mejorar y evaluar los resultados de la educación. Sin embargo, como ocurre con cualquier reforma importante, hay retos que superar, como la necesidad de recursos adicionales, la necesidad de alinear mejor el sistema educativo con las demandas cambiantes del mercado laboral y la necesidad de garantizar que todos los estudiantes, independientemente de su procedencia, tengan acceso a una educación de alta calidad.

**Prof. Fredy H. Martínez S., Ph.D**

Docente Facultad Tecnológica

Universidad Distrital Francisco José de Caldas

# Editorial

*T*he Colombian education model has undergone significant changes in recent years, moving from a traditional model focused on rote memorization and teacher-centered instruction to a competency-based model that emphasizes the acquisition of skills and the development of critical thinking abilities. One of the key elements of this transition has been the implementation of the National Curriculum Guidelines, which outline the competencies that students are expected to acquire at each grade level. These competencies are organized into four categories: cognitive (knowledge and understanding), psychomotor (skills and abilities), affective (values and attitudes), and communicative (language and communication).

The competency-based model is intended to foster a more active and self-directed approach to learning, as well as to ensure that students have the skills and knowledge they need to succeed in the 21st century. To support this transition, the Colombian government has invested in the development of new curricula and teaching materials, as well as in the training of teachers. The current learning outcomes model of Colombia is based on the principles of the competency-based education model. It is focused on the acquisition of knowledge, and the development of competencies and values, through a continuous and holistic evaluation of the student. Uses a system of annual, semi-annual, and final evaluations, that evaluate each of the competencies. This evaluation system also establishes that the grades obtained by students must be a weighted average of the evaluations of the competencies.

Overall, the Colombian education model is designed to prepare students for success in a rapidly changing world, by fostering the development of critical thinking skills, a love of learning, and a commitment to civic engagement. The country has made big efforts in recent years for the transition to a competency-based model and is currently working on the development and implementation to improve and evaluate the education outcome. However, as with any major reform, there are challenges to be overcome, such as the need for additional resources, the need to better align the education system with the changing demands of the labor market, and the need to ensure that all students, regardless of their background, have access to a high-quality education.

**Prof. Fredy H. Martínez S., Ph.D**

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# Docker: A tool for creating images and launching multiple containers with ROS OS

*Docker: Una herramienta para crear imágenes y lanzar múltiples contenedores con ROS OS*

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Docker is a tool that allows to create containers with everything needed to run an application. This feature makes it key to the process of transferring software products in different environments, allowing code to be ported faster, with better use of resources, and more reliably. ROS 2 (Robot Operating System 2) is an open source SDK for robotics applications that provides hardware abstraction for control, which can benefit from the use of containers. This article presents an introduction to Docker, creating images, launching multiple containers, and most importantly, how it can be used in conjunction with ROS OS for robotics applications.

*Keywords:* Container, docker, image, robotics, ROS

Docker es una herramienta que permite crear contenedores con todo lo necesario para ejecutar una aplicación. Esta característica la convierte en clave para los procesos de transferencia de productos software en diferentes entornos, al permitir transferir código con mayor rapidez, mejor uso de recursos, y de forma más confiable. ROS 2 (Robot Operating System 2) es un SDK de código libre para aplicaciones en robótica que proporciona abstracción del hardware para el control, que puede verse beneficiado por el uso de contenedores. En este artículo se presenta una introducción a Docker, la creación de imágenes, el lanzamiento de múltiples contenedores, y sobre todo, cómo se puede utilizar en conjunto con ROS OS para aplicaciones de robótica.

*Palabras clave:* Contenedor, docker, imagen, robótica, ROS

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## Introduction

In robotics and software development in general, you normally need different applications to interact among them (Baltes & Diehl, 2018). This is necessary to ensure the smooth flow of data and information between different systems so that they can work in tandem with one another (Martínez, 2021). However, in many cases, certain software requires specific conditions in the operating system and library versions that make it complex to run on any other machine (Martínez et al., 2018). As a result, it is often difficult to maintain compatibility between different applications and software programs.

The only thing that never changes in the software development sector is change (Immaculate et al., 2019). This implies that software is constantly changing to meet changing demands. If automated testing does not adequately cover a change when it occurs, something is likely to break. As such, software developers must keep up with the changing landscape, constantly updating and refining the software they develop to remain competitive. To ensure this happens, software developers must have a robust automated testing process in place to quickly identify any changes in the software that could cause an unexpected break.

In a computing context, "permissions" refer to the ability of a user or system process to access and make changes to certain files or folders on a computer (Feng et al., 2019). When you change the permissions on a file, you are altering what actions other users or processes can perform on that file (Han et al., 2020). For example, you might give a group of users read-only access to a file, meaning they can view the contents of the file but cannot make any changes to it. Sometimes, it is necessary to change permissions on a file to allow certain processes to run or to restrict access to sensitive information. However, making changes to permissions can also have unintended consequences. If you change the permissions on a file that is essential to the operation of your system, it may cause problems or errors to occur. Similarly, deleting a folder or changing a configuration file can also cause problems. Configuration files contain important settings and instructions that tell your system how to operate. If you delete a configuration file or alter it in a way that is incompatible with your system, it could cause your system to malfunction. It is important to be careful when making changes to the permissions, files, or folders on your system. If you do need to make changes, it is a good idea to test the changes in a controlled environment before implementing them on your production system. This will allow you to identify any potential problems and fix them before they cause issues for your users. If something does go wrong after you have made changes to your system, it can be difficult to diagnose the problem. If you have only changed a single file, it may be easier to track down the cause of the problem. However, if you have installed, deleted, or

updated software, or changed folder permissions recursively (meaning that the changes were applied to all subfolders and files within a folder), it may be more challenging to identify the root cause of the issue. In these cases, it may be necessary to perform a thorough analysis of your system to determine what has caused the problem and how it can be fixed.

Docker is a tool that allows developers to package applications in containers, which are lightweight and portable software packages that include all of the necessary dependencies and libraries needed to run an application (Pan et al., 2019). Using Docker can help to solve many of the problems that can occur when running and deploying applications. One major benefit of Docker is that it allows you to create a consistent environment for your application to run in. When you create a Docker image, it is a snapshot of your application and all of its dependencies at a specific point in time. This means that once you have created a Docker image, it will never change. This is in contrast to traditional application deployment methods, where it is common for applications to be updated and modified over time. With Docker, you can be confident that your application will always run in the same way, regardless of any changes that may have been made to the host operating system or other software on the system.

Another advantage of Docker is that it makes it easy to share applications with others (Diekmann et al., 2019). Once you have created a Docker image, you can share it with anyone else, and they should be able to run the application in the same way that you do. This is because the Docker image includes all of the necessary dependencies and libraries needed to run the application, and these are bundled together in a single package. This means that there is no need to worry about configuring the environment or installing additional software to run the application. Overall, Docker provides a reliable and consistent way to run and deploy applications, and it can help to avoid many of the problems that can occur when running applications in traditional environments. By using Docker, you can be confident that your application will always run in the same way, no matter how many times you try.

When you create a Docker image, you are taking a snapshot of your application and all of its dependencies at a specific point in time. This image serves as a template for creating containers, which are essentially running instances of the image. If you want to run your application in a Docker container, you simply create a new container from the image and start it up.

One of the key advantages of this approach is that it allows you to be sure that you can always replicate the same environment for your application (Moreno et al., 2022). Because the image contains all of the necessary dependencies and libraries, you can be confident that your application will run in the same way every time you create

a new container from the image. This means that you can be sure that you can always replicate the same results when you run your application, regardless of the environment or platform you are using.

It is possible to install or update different applications within a Docker container, but these changes will not affect the original image. Instead, they will only be applied to the running container (Akhilesh et al., 2021). If you want to make changes to the original image, you will need to create a new image with the same label as the original image, replacing it. This allows you to easily create new versions of your application while still preserving the original image as a reference point.

In the software industry, it is common for companies to use applications developed by other parties. These applications may be off-the-shelf software products that are widely available, or they may be custom-built applications that have been developed specifically for the company. While most software is developed with good intentions and is generally reliable, there are instances where problems can occur.

One potential problem with using software developed by others is the risk of critical bugs or vulnerabilities. A bug is a mistake or error in the code of an application, and it can cause the application to behave unexpectedly or fail to function properly. A critical bug is a bug that has the potential to cause serious problems or disruptions. For example, a critical bug might allow an attacker to gain unauthorized access to a system or steal sensitive information.

Another risk of using software developed by others is the potential for malicious or maliciously-crafted applications. In some cases, software may be developed with the intention of causing harm or exploiting vulnerabilities in systems. For example, an attacker might develop a malicious application that appears to be legitimate software, but which contains hidden code that allows the attacker to gain access to a system and steal sensitive information.

When you create a Docker container, you can specify which resources on your computer the container has access to. For example, you can specify how much memory and CPU a container can use, as well as which files or folders the container has access to. This allows you to control the impact that the container has on your system, and to ensure that it does not consume more resources than you are willing to allocate to it.

You can also specify the permissions that a container has when accessing resources on your system. For example, you can make a file or folder read-only, meaning that the container can view the contents of the file but cannot make any changes to it. This helps to prevent accidental or malicious modification of important resources on your system.

Using Docker allows you to have full control over your computer, as you can specify exactly which resources containers have access to and what permissions they have when accessing those resources. This can help to protect your system from potential problems or vulnerabilities that may arise when running containers.

### Literature review

In ROS OS, the files are in XML format and are difficult to write and understand for nontechnical users. To address this problem (Narayanamoorthy et al., 2015) propose a visual programming software tool that helps in the creation and visualization of these ROS launch files. (Naik, 2016a) present the simulation of building a virtual system of systems (SoS) for the distributed software development process on multiple clouds. (Naik, 2016b) present the simulation and evaluation of the development of a distributed system using virtualization and dockerization. (Kelley et al., 2016) propose a quantum network security framework for the cloud. They also decrease the overall security, as each included component-necessary or not-may bring in security issues of its own, and there is no isolation between multiple applications packaged within the same container image. (Rastogi et al., 2017) propose algorithms and a tool called Cimplifier, which address these concerns: given a container and simple user-defined constraints, the tool partitions it into simpler containers, which (i) are isolated from each other, only communicating as necessary, and (ii) only include enough resources to perform their functionality. Recent massive data projects have revealed several bottlenecks for projects with >100,000 assessors (i.e., data processing pipelines in XNAT). In order to address these concerns (Damon et al., 2017) develop a new API, which exposes a direct connection to the database rather than REST API calls to accomplish the generation of assessors. The live migration may cause significant delays when the applications running inside a container modify large amounts of memory faster than a container can be transferred over the network to a remote host. (Stoyanov & Kollingbaum, 2018) propose a novel approach for live migration of containers to address this issue by utilizing a recently published CRIU feature, the so-called “image cache/proxy”. To reduce the barrier for newcomers and to prevent deprecation of aging software (East et al., 2019) create the NMRdock container. Other influential work includes (Chouhan et al., 2021; Trapti Gupta and Abhishek Dwivedi, 2017).

### Docker Images

Docker is a software tool that simplifies software’s building, running, managing, and distributing. It works by virtualizing a computer’s operating system, on which the software is installed and executed. In this sense, Docker works as a box in which it can install an application under

specific operating system conditions and keep it running in isolation from the rest of the existing software on the machine. In principle, each software is isolated in its box or container and therefore does not interfere with other existing software, which generally happens on a personal computer. This occurs easily when working in an application development environment and when desired to guarantee that the application under development will run the same way in any other machine (everything always works the same inside the box, which can be inside a robot).

The first step is to install Docker on the local machine or host. For Linux Mint, Ubuntu, MX Linux and other Debian derivatives, in a terminal window run one by one the following commands:

```
sudo apt update
sudo apt install docker.io docker-compose
```

And then the Docker service is started:

```
sudo service docker start
```

At this point it is possible to use Docker commands. To be able to use the docker command from any user and without the need of the sudo command, it is necessary to add it to the docker group:

```
sudo usermod -aG docker $USER
newgrp docker
```

Docker can also be installed natively on Windows 10 onwards (for Windows 7 and 8 it is necessary to use Virtualbox). In the case of not having virtualization enabled, Docker will detect this feature in the installation process and will ask to install it automatically. To check it, you can use the *Task Manager*. Docker Desktop for Windows can be downloaded from this link:

<https://docs.docker.com/desktop/install/windows-install/>

Download and double click on the file to install. When finished Docker runs automatically.

The next step will always be to ensure that there is no ROS publisher or subscriber running by previous jobs. These can be stopped with the key combination **CTRL + C** on each of the terminals. The box where the software is isolated for execution is called Docker Image. Pulling a Docker image means downloading a Docker image to a local location (our computer, for example) from some repository. For example, let's pull a Docker image that contains ROS Foxy, in a terminal type:

```
docker pull ros:foxy-ros-base
```

This command produces in the terminal a response similar to the one shown in Fig. 1, which indicates that the image is pulling a Docker image that contains Docker ROS Foxy

installed (note the Status line at the end). The `docker pull` command is used to pull an image from a registry. Now, what if we want to work with ROS Noetic? In this case, to work with this other Distro, we simply download the desired image, which can be done with the following command:

```
docker pull ros:noetic-ros-core
```

Note that both are done with a simple command, and in neither case was it necessary to install them on the computer. To determine which Docker images are available, check with the following command:

```
docker images
```

Additional help for the `docker pull` command can be obtained as follows:

```
docker pull --help
```

This help provides the general structure for the command (as for any other). Therefore, the commands used before referenced an image named `ros` that has a tag named `foxy-ros-base` (or `noetic-ros-core`). Because of our approach `ros` was used, but in general any Linux distro can be used, for example Ubuntu 20.04:

```
docker pull ubuntu:20.04
```

Thus, a third image is now available. Images downloaded and available on the local machine can be run with the `docker run` command, which must be fed with the image name. When a ROS image is executed, it becomes available for use.

```
docker run [OPTIONS] IMAGE [COMMAND] [ARG...]
```

As an example, let's run one of the downloaded and available images:

```
docker run -it --name my_ros ros:foxy-ros-base bash
```

This command uses some run options, `-it` indicates to run on an interactive terminal inside the container, `-name` assigns a name to the container where the image will be executed, and the `bash` option indicates to run on a terminal.

The container with the image can be seen as a normal computer as well as the local machine where it runs. There it can run pretty much all the commands you run on our own computer (host), but everything is still isolated from the host. It should be able to create own `ros2` workspaces, and put code there, and that would not affect the files on the host. You should be able to create your `ros2` workspaces and put code there, which would not affect your files. For this,



**Figure 1***Pulling a Docker image.*

```

$ docker pull ros:foxy-ros-base
foxy-ros-base: Pulling from library/ros
675920708c8b: Pull complete
7cf19bc0e0d1: Pull complete
ff483ca449e2: Pull complete
077f60b8d79e: Extracting [=====>]          227B/227B
c152c32a5dfa: Download complete
f6e812731a44: Downloading [=====>]          ] 16.15MB/120.1MB
430ce07703bc: Download complete
1890f880d76a: Downloading [>]                ] 1.08MB/73.32MB
6d1250a90908: Waiting
67e10b955d67: Waiting
7586ba8a5351: Pulling fs layer
[]

```

inside the container we will create the folder `/home/user`, with a folder inside it called `ros2_test` that will become our workspace. At the end we compile. The following commands do these tasks.

```

mkdir -pv /home/user/ros2_test/src
cd /home/user/ros2_test
source /opt/ros/foxy/setup.bash
colcon build

```

As it is obvious, it is possible to run multiple containers on the same local machine, the running containers can be listed as follows in the terminal (from outside of them, of course, for example on another terminal):

```
docker ps
```

If the containers have not been stopped, the container information will be displayed detailing the image used, the total execution time, its status, and the name assigned when it was executed (`my_ros` in our case). To exit a container, use the key combination `CTRL+D`. When a container is terminated, its activity will no longer be logged with the `docker ps` command. However, an error will appear if you try to rerun it with the same name, indicating that it already exists and is in use. This is because the container was stopped, but the process still exists, so it would be necessary to kill it. To see all the containers independent of their status, the following command is used:

```
docker ps -a
```

The following command is used to remove a container from memory:

```
docker rm my_ros
```

For a complete list of available commands use the command:

```
docker --help
```

The docker images we pulled previously came from <https://hub.docker.com/>. Docker Hub is a service provided by Docker for finding and sharing container images (cloud-based registry). If there is a popular software you like, it is very likely that you will find its docker image on Docker Hub. How to create your own Docker image, and how to make it publicly available, will be detailed later.

### Docker Network and Docker Compose

One important aspect of running applications in containers is networking. Docker provides several options for connecting containers and to the outside world. In this article, we'll explain the basics of Docker networking and how to use Docker Compose to easily launch multi-container applications.

#### Docker networking basics

In Docker, a network is a group of interconnected containers. By default, each container in Docker is given its own network stack, with its own IP address. This allows containers to communicate with each other and the outside world, as long as they are on the same network. Several different types of networks can be created in Docker:

- **bridge:** This is the default network type in Docker. It creates a private network for containers, which is isolated from the host and other networks. Containers on the same bridge network can communicate with each other using their IP addresses.
- **host:** This network type bypasses the network isolation provided by the Docker daemon, and instead uses the host's networking stack. Containers on the host network can communicate with each other and the host using their IP addresses.
- **none:** This network type disables networking for a container.

- **overlay:** This network type enables containers to communicate across multiple Docker daemons, allowing containers to span multiple hosts.

In addition to these network types, Docker also provides some additional networking features, such as aliases, links, and networks.

## Launching multi-Container applications with Docker Compose

While it's possible to launch multi-container applications using the `docker run` command, it can be cumbersome to specify all of the necessary configuration in the command line. That's where Docker Compose comes in.

Docker Compose is a tool for defining and running multi-container Docker applications. It allows you to use a YAML file to specify the details of your application's containers, networks, and volumes. Then, with a single command, you can create and start all of the containers specified in the Compose file.

A simple example of a Docker Compose file is as follows:

```
version: '3'
services:
  web:
    build: .
    ports:
      - "8000:8000"
    volumes:
      - ./code
  redis:
    image: redis:alpine
```

This Compose file defines a single service, `web`, which is built from the current directory and exposes port 8000. It also defines a `redis` service, which is run from the `redis:alpine` image.

To launch the containers defined in this Compose file, you can use the `docker-compose up` command. This will build the `web` service if necessary, and start both the `web` and `redis` containers.

You can also use Compose to run commands in your containers. For example, to run a command in the `web` container, you can use the `docker-compose run` command:

```
docker-compose run web python manage.py migrate
```

This will start the `web` container if it's not already running, and then run the `python manage.py migrate` command inside the container.

## Understanding Docker Compose

To understand Docker Compose, it's important to understand the key concepts it uses:

- **Services:** A service is a container that is running as part of a multi-container application. Each service is defined in the Compose file with a unique name and can be configured with various options, such as the image to use, port mappings, and environment variables.
- **Networks:** In Docker Compose, you can create custom networks for your services to connect to. This allows you to specify which services can communicate with each other, and how they can communicate.
- **Volumes:** Volumes are persistent storage for your containers. You can use volumes to share data between containers, or to persist data outside of a single container's lifecycle.
- **Compose file:** The Compose file is a YAML file that defines the details of your multi-container application, including the services, networks, and volumes.

With these concepts in mind, let's take a closer look at the structure of a Docker Compose file. The top-level keys in a Compose file are `version`, `services`, `networks`, and `volumes`.

- **version** specifies the version of the Compose file format. This is used to ensure that the file is compatible with the version of Docker Compose you are using.
- **services** defines the containers that make up your application. Each service is given a unique name and can be configured with various options, such as the image to use, port mappings, and environment variables.
- **networks** allows you to create custom networks for your services to connect to. You can specify which services should be connected to which networks, and configure the network's driver and other options.
- **volumes** allows you to define named volumes that can be shared between containers, or used to persist data outside of a single container's lifecycle.

Here's an example of a more complete Docker Compose file that includes all of these top-level keys:

```
version: '3'
services:
  web:
    build: .
    ports:
      - "8000:8000"
    volumes:
      - ./code
      - logvolume:/var/log
  redis:
    image: redis:alpine
```

```
volumes:
  - redis-data:/data
networks:
  default:
    driver: bridge
volumes:
  logvolume:
  redis-data:
```

This Compose file defines a web service that is built from the current directory and exposes port 8000, and a redis service that is run from the `redis:alpine` image. It also defines two named volumes, `logvolume` and `redis-data`, which are used to persist data for the web and redis services respectively. Finally, it creates a default network using the bridge driver and connects the web and redis services to it.

With this Compose file, you can use the `docker-compose` up command to launch all of the containers in your multi-container application. You can also use the `docker-compose run` command to execute commands in your containers, or the `docker-compose down` command to stop and remove the containers. Docker Compose is a powerful tool for developing and deploying multi-container applications. By using a Compose file, you can easily launch and manage your containers with a single command.

### Docker with ROS

Now let's look at a demonstration of how to use ROS with Docker. In a terminal (we'll call it terminal window 1) we first download and run ROS Noetic:

```
docker pull ros:noetic-ros-core
```

Then we execute, in the same terminal 1, `roscore` (Fig. 2):

```
docker run -it ros:noetic-ros-core roscore
```

In the previous command we did not specify a name for the container, so Docker will assign one to it. And now, let's try to access from another terminal (new terminal window, which we will call terminal 2) to the bash of the container, and run the `rostopic list` command there:

```
docker run -it ros:noetic-ros-core bash
```

And then the command:

```
rostopic list
```

However this produces an error, indicating that communication is impossible, this indicates that each terminal is running in a different container (you can verify in another terminal that each container has a different name, but both use the same image), and it is not possible for them to communicate with each other. They could communicate

if the containers share the same network as the host. To do this, let's start again by exiting the two containers loaded with ROS Noetic (press CTRL+C in terminal 1, and CTRL+D in the terminal 2 window), and then run the following in terminal 1:

```
docker run -it --net=host ros:noetic-ros-core roscore
```

And similarly in terminal 2:

```
docker run -it --net=host ros:noetic-ros-core bash
```

And then the command:

```
rostopic list
```

This time it does produce the expected response (see the topics, Fig. 3).

Now, let's start a publisher node in ROS2. In terminal 1 we press the CTRL+C keys and then type:

```
docker run -it ros:foxy-ros-base bash
```

And then, in the same terminal 1, we will publish a topic:

```
ros2 topic pub /test std_msgs/msg/String "data: Hello there!"
```

This makes that in the terminal this publication is seen in a cyclical way. Now in the terminal 2 we press the keys CTRL+D and we access in a new container:

```
docker run -it ros:foxy-ros-base bash
```

And there we listen with the following command (Fig. 4):

```
ros2 topic list
```

In fact, in terminal 2 we can subscribe to the topic that is being published, and listen to it cyclically:

```
ros2 topic echo /test
```

To stop and terminate the two containers, press the key combination CTRL+C and CTRL+D on terminals 1 and 2. The containers can be removed with the `docker rm` command.

### Project Example

This is an example of how to use Docker with the Robot Operating System (ROS). This example assumes that Docker is already installed on the system.

1. Create a directory for your ROS application. This will be the base directory for your Docker project.

**Figure 2**

*Roscore launching.*

```
$ sudo docker run -it ros:noetic-ros-core roscore
... logging to /root/.ros/log/44848c48-3d27-11ed-9f40-0242ac110002/roslaunch-600f209c9c78-1.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://600f209c9c78:40693/
ros_comm version 1.15.14

SUMMARY
=====

PARAMETERS
* /rostdistro: noetic
* /rosversion: 1.15.14

NODES
auto-starting new master
process[master]: started with pid [32]
ROS_MASTER_URI=http://600f209c9c78:11311/

setting /run_id to 44848c48-3d27-11ed-9f40-0242ac110002
process[rosout-1]: started with pid [42]
started core service [/rosout]
```

**Figure 3**

*Topics listened through the host network.*

```
$ sudo docker run -it --net=host ros:noetic-ros-core bash
[sudo] password for fredymar:
root@mx:/# rostopic list
/rosout
/rosout_agg
root@mx:/#
```

**Figure 4**

*Topics listened in ROS2.*

```
[sudo] password for fredymar:
root@e8bbaf4de5e8:/# ros2 topic list
/parameter_events
/rosout
/test
root@e8bbaf4de5e8:/#
```

2. Create a file called Dockerfile in the base directory. This file will contain the instructions for building your Docker image.
3. In the Dockerfile, specify the base image that you want to use for your ROS application. There are several official ROS images available on Docker Hub, including ros, ros-core, and ros-base. For this example, we will use the ros-core image, which includes ROS, the roscpp and rospy libraries, and other core ROS packages.

4. In the Dockerfile, copy the necessary files for your ROS application into the image. For example, you might copy your ROS nodes and launch files into the /ros\_ws/src directory in the image.
5. In the Dockerfile, install any additional dependencies that your ROS application requires. For example, you might install additional ROS packages using the ROS\_PACKAGE\_PATH environment variable.
6. In the Dockerfile, specify the command to run when the container is launched. For example, you might specify a command to run a launch file for your ROS application.
7. Build the Docker image using the docker build command. For example:

```
docker build -t my_ros_app .
```

8. Run the Docker container using the docker run command. For example:

```
docker run --rm -it my_ros_app
```

This will launch the container and run the command specified in the Dockerfile.

Alternatively, you can use Docker Compose to launch multiple containers for a single ROS application. To do this,

you will need to create a `docker-compose.yml` file in the base directory of your project. This file will specify the different containers and their configurations, as well as any networks and volumes that they should be connected to.

Here is an example `docker-compose.yml` file for a ROS application:

```
version: '3'
services:
  ros_master:
    image: ros:melodic-ros-core
    hostname: ros_master
    networks:
      - ros_network
  ros_node:
    image: my_ros_app
    hostname: ros_node
    networks:
      - ros_network
    environment:
      - ROS_MASTER_URI=http://ros_master:11311
      - ROS_HOSTNAME=ros_node
networks:
  ros_network:
    driver: bridge
```

This Compose file defines two services, `ros_master` and `ros_node`, which are connected to a custom `ros_network` using the `bridge` driver. The `ros_master` service is based on the `ros:melodic-ros-core` image and is given the hostname `ros_master`. The `ros_node` service is based on the `my_ros_app` image that we built earlier and is given the hostname `ros_node`. The `ros_node` service also specifies the `ROS_MASTER_URI` and `ROS_HOSTNAME` environment variables, which are used to configure the ROS network. The `ROS_MASTER_URI` variable specifies the URL of the ROS master node, which is running on the `ros_master` container. The `ROS_HOSTNAME` variable specifies the hostname of the `ros_node` container.

To launch the containers defined in this Compose file, you can use the `docker-compose up` command:

```
docker-compose up
```

This will start the `ros_master` and `ros_node` containers and connect them to the `ros_network`. The `ros_master` container will function as the ROS master node, and the `ros_node` container will function as a ROS node that is connected to the master node.

You can also use the `docker-compose run` command to execute commands in the `ros_node` container. For example, to run a ROS node in the `ros_node` container, you can use the following command:

```
docker-compose run ros_node roslaunch my_ros_package my_ros_node
```

This will start the `ros_node` container if it's not already running, and then run the `roslaunch my_ros_package my_ros_node` command inside the container.

## Conclusion

Docker is a powerful tool for running and managing applications in containers. Containers allow developers to package up an application with all of its dependencies and ship it as a single package, making it easier to deploy and manage applications in different environments.

One important aspect of running applications in containers is networking. Docker provides several options for connecting containers and to the outside world, including bridge, host, and overlay networks.

Docker Compose is a tool for defining and running multi-container Docker applications. It allows developers to use a YAML file to specify the details of their application's containers, networks, and volumes, and then launch all of the containers with a single command.

In the field of robotics, Docker and Docker Compose can be especially useful for developing and deploying applications on the Robot Operating System (ROS). ROS is a powerful open-source framework for building robot applications, but it can be challenging to install and manage all of the necessary dependencies. By using Docker and Docker Compose, developers can package up their ROS applications and all of their dependencies into a single container, making it easier to deploy and manage their applications on different platforms.

Additionally, Docker Compose can be used to launch multiple containers for a single ROS application, making it easier to manage the different components of the application. For example, a ROS application might consist of a main control node, a sensor node, and a visualization node, each of which can be run in its container. By using Docker Compose, these containers can be launched and managed with a single command.

Overall, Docker and Docker Compose are powerful tools for developing and deploying applications, including those built with ROS. By using these tools, developers can package up their applications and dependencies into containers, making it easier to deploy and manage their applications on different platforms.

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# How to choose an activation function for deep learning

*Cómo elegir una función de activación para el aprendizaje profundo*

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Activation functions are important in each layer of the neural network because they allow the network to learn complex relationships between the input data and the output data. They also introduce nonlinearity into the network, which is essential for learning patterns in data. Activation functions play a critical role in the training and optimization of deep learning models, and choosing the right activation function can significantly impact the model's performance. This article presents a summary of the features of these functions.

*Keywords:* Activation function, deep learning, neural network, nonlinearity

Las funciones de activación son importantes en cada capa de la red neuronal porque permiten a la red aprender relaciones complejas entre los datos de entrada y los de salida. También introducen la no linealidad en la red, que es esencial para aprender patrones en los datos. Las funciones de activación desempeñan un papel fundamental en el entrenamiento y la optimización de los modelos de aprendizaje profundo, y la elección de la función de activación adecuada puede influir significativamente en el rendimiento del modelo. Este artículo presenta un resumen de las características de estas funciones.

*Palabras clave:* Aprendizaje profundo, función de activación, no linealidad, red neuronal

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## Introduction

Activation functions play a crucial role in deep learning and can greatly impact the performance of a neural network (Kim & Cho, 2019). Choosing the right activation function can be challenging, as there are a wide variety of options to choose from and the optimal choice may depend on the specific characteristics of the data and the problem being solved (Maguolo et al., 2019). In this paper, we will explore the most important considerations when selecting an activation function for deep learning.

One of the primary considerations when selecting an activation function is the range of the output (Martínez, Martínez, & Montiel, 2020). Activation functions that produce output in a limited range, such as between 0 and 1 or between -1 and 1, can be more stable and easier to train than those with a wider range (Montiel et al., 2021). Sigmoid and Tanh are examples of activation functions that produce output in a limited range, while ReLU (Rectified Linear Unit) has a range of 0 to infinity.

Another important consideration is the shape of the activation function. Activation functions with a smooth, continuous curve can help the neural network to converge faster and perform better, as the gradient is well-behaved and easy to compute (Rendón & Martínez, 2021). On the other hand, activation functions with a more complex or discontinuous curve can be more difficult to optimize and may lead to slower convergence (Alonso et al., 2021). For example, the Sigmoid function has a smooth curve, while the ReLU function has a piecewise linear shape.

In addition to the range and shape of the activation function, it is also important to consider the computational efficiency of the function (Martínez et al., 2022). Activation functions that require more computation, such as Sigmoid and Tanh, can be more expensive to compute and may slow down training (Jacinto et al., 2022). On the other hand, activation functions that are more computationally efficient, such as ReLU and its variants, can speed up training and make it more efficient.

Another important factor to consider when selecting an activation function is the ability to handle non-linearity (Martínez, Martínez, & Jacinto, 2020). Neural networks are able to model complex relationships and patterns in data due to their ability to learn non-linear functions (Martínez, Penagos, et al., 2020). Activation functions that are able to introduce non-linearity into the network can help the network to better capture these patterns and improve its performance (Montiel et al., 2017). However, it is important to find the right balance between introducing non-linearity and maintaining stability, as too much non-linearity can lead to overfitting and poor generalization.

It is also worth considering the vanishing gradient problem when selecting an activation function (Rendón et al., 2017). During training, the gradients of the weights in

the neural network are updated based on the error between the predicted output and the true output. If the gradients are too small, the network may have difficulty learning and convergence may be slow (Martínez et al., 2017). Activation functions that have a slope close to 0 for large input values can lead to the vanishing gradient problem, as the gradients will be small and the network will have difficulty learning. On the other hand, activation functions that have a slope that remains relatively large for a wide range of input values can help to mitigate the vanishing gradient problem and improve the network's ability to learn.

Finally, it is also worth considering the specific characteristics of the data and the problem being solved when selecting an activation function. Some activation functions may be better suited for certain types of data or problems, while others may be less effective. For example, Sigmoid and Tanh may be more effective for binary classification problems, while ReLU may be better suited for regression tasks.

In summary, there are a number of important considerations when selecting an activation function for deep learning. These include the range and shape of the output, computational efficiency, ability to handle non-linearity, and the vanishing gradient problem. It is also important to consider the specific characteristics of the data and the problem being solved.

## Literature review

(Deng et al., 2013) provide an overview of the invited and contributed papers presented at the special session at ICASSP-2013, entitled "New Types of Deep Neural Network Learning for Speech Recognition and Related Applications," as organized by the authors. (Chang & Tsai, 2017) choose to use exponential linear units (ELUs) as the activation function and stochastic gradient descent (SGD) as the optimizer. (Ramachandran et al., 2017) propose to leverage automatic search techniques to discover new activation functions. (X. Zhu et al., 2018) propose a new method based on a multilayer perceptron (MLP), a classic network in deep learning, to predict the EDH. Auto-Encoder will be utilised as a feature learning algorithm to practice the recommended model to excerpt the useful features from the surface electromyography signal (Ibrahim & Al-Jumaily, 2018). Based on the big data of rail transit IC card (Public Transportation Card) (H. Zhu et al., 2018) analyze the data of major dynamic factors having effect on entrance passenger flow and exit passenger flow of rail transit stations: weather data, atmospheric temperature data, holiday and festival data, ground index data, and elevated road data and calculates the daily entrance passenger flow and daily exit passenger flow of individual rail transit stations with data reduction. Krizhevsky outlines the construction of an image recognition model using the Rectified Linear Unit activation function



(ReLU) for the ImageNET LSVRC-2010 competition which outperformed the state-of-the-art image recognition systems at the time (Pomerat et al., 2019). (Szandala, 2021) evaluate the commonly used additive functions, such as swish, ReLU, Sigmoid, and so forth. There is no existing work that provides sound information for peers to choose appropriate deep AUROC maximization techniques. (D. Zhu et al., 2022) fill this gap, they compared the existing top ten loss functions (pairwise or composite) for deep maximization of AUROC. They performed experiments on six image datasets and six molecule graph datasets. The large-scale CheXpert dataset contains 191,027 samples and five recognition targets.

### Problem statement

The activation functions are fundamental for the design of a neural network, this activation function allows for example in the hidden layer to verify how well the network model learns with the training data provided, so it is important a good choice of the function because in the outputs we will see the predictions that the model presents us.

Something that we will learn with this article and that is very important is:

- Activation functions are a key part of neural network design.
- The modern default activation function for hidden layers is the ReLU function.
- The activation function of the output layers depends on the type of prediction problem.

This paper is divided into three parts:

- Activation functions
- Activation of Hidden Layers
- Activation for output layers

### Activation functions

An input weighted sum that is converted into an output of one or more nodes in a layer of a neural network is known as an activation function in a neural network. Since many activation functions are not linear, the design of the network or layer is non-linear, as is well known (Non-linearity).

On the other hand, the activation function is often referred to as a transfer function, but if the output range of the activation function is limited, then it can be called a squashing function.

A good choice or choices of the activation function will allow the neural network to have good capacity and performance, basically, the activation function can be used within or after the processing of each node in the network, although we know that networks are designed to use the same

activation function for all nodes in a layer. On the other hand, it is necessary to know that activation functions are also usually differentiable, which means that the first order derivative can be calculated for a given input value. This is because neural networks are usually trained using the error back propagation algorithm that requires the derivative of the prediction error to update the model weights.

Therefore, the hidden layers usually use the same activation function, but the output layer will use a different activation function from the hidden layers, this may be because of the type of prediction required by the model.

The network is composed of three different types of layers: input layers, which take the domain's raw input, hidden layers, which take the input from another layer and transmit the acquired output to another layer, and output layers, which perform the prediction.

### Activation of hidden layers

A hidden layer in a neural network is one that, in general, neither directly interacts with input data nor produces outputs for models; rather, it accepts input from other layers as another input layer and permits output to other layers as an output layer.

A neural network may contain zero hidden layers or more. In the hidden layers of a neural network, a nonlinear differentiable function is frequently utilized for the activation function. In comparison to a network trained using a linear activation function, the model can learn more complicated functions as a result.

There are three activation functions that can be considered for use in hidden layers:

- Rectified Linear Activation (ReLU).
- Logistic (Sigmoid)
- Hyperbolic Tangent (Tanh)

### ReLU hidden layer activation function

The most typical function employed in hidden layers is the rectified linear activation function, or ReLU activation function.

It is popular because it is easy to use and gets around the drawbacks of other activation algorithms like Sigmoid and Tanh. It can experience other issues like saturated units, but it is less prone to vanishing gradients that prohibit deep models from being trained.

This is how the ReLU function is determined:

$$\max(0.0, x) \quad (1)$$

Accordingly, a value of 0.0 is returned if the input value  $x$  is negative; otherwise, the value is returned. The solved

**Figure 1**

Example of the ReLU activation function.

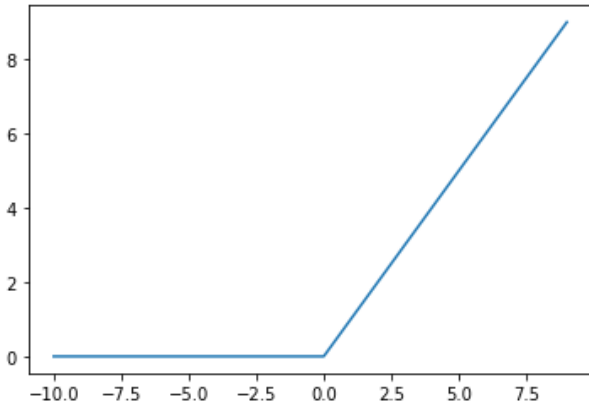
```
# example plot for the relu activation function
from matplotlib import pyplot

# rectified linear function
def rectified(x):
    return max(0.0, x)

# define input data
inputs = [x for x in range(-10, 10)]
# calculate outputs
outputs = [rectified(x) for x in inputs]
# plot inputs vs outputs
pyplot.plot(inputs, outputs)
pyplot.show()
```

**Figure 2**

Input vs. output graph for ReLU activation function.



example below can be used to get a general idea of the shape of this function (Fig. 1).

When the example is run, the outputs are calculated for a variety of values, and an input-to-output graph is produced (Fig. 2). We can see the ReLU activation function's well-known kink shape.

### Sigmoid hidden layer activation function

The logistic function is another name for the sigmoid activation function. The logistic regression classification approach uses the same function.

The function produces numbers between 0 and 1 and accepts any real value as an argument. The output value will be nearer to 1.0 the greater the input, or positive, whereas the output will be nearer to 0.0 the smaller the input, or negative. 0.0 will be the result.

**Figure 3**

Example of the Sigmoid activation function.

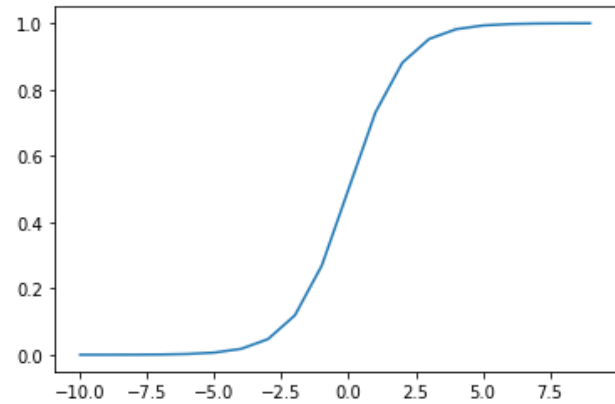
```
# example plot for the sigmoid activation function
from math import exp
from matplotlib import pyplot

# sigmoid activation function
def sigmoid(x):
    return 1.0 / (1.0 + exp(-x))

# define input data
inputs = [x for x in range(-10, 10)]
# calculate outputs
outputs = [sigmoid(x) for x in inputs]
# plot inputs vs outputs
pyplot.plot(inputs, outputs)
pyplot.show()
```

**Figure 4**

Input vs. output plot for Sigmoid activation function.



Following are the calculations for the sigmoid activation function (Eq. 2).

$$\frac{1.0}{(1.0 + e^{-x})} \quad (2)$$

Where the natural logarithm's base, e, is a mathematical constant. With the help of the below-mentioned example's solution, we can acquire a general idea of this function's shape (Fig. 3).

When the example is run, the outputs are calculated for a range of values, and an input-to-output plot is produced. It is possible to view the sigmoid activation function's well-known S-shape (Fig. 4).

**Figure 5**

Example of the Tanh activation function.

```

# example plot for the tanh activation function
from math import exp
from matplotlib import pyplot

# tanh activation function
def tanh(x):
    return (exp(x) - exp(-x)) / (exp(x) + exp(-x))

# define input data
inputs = [x for x in range(-10, 10)]
# calculate outputs
outputs = [tanh(x) for x in inputs]
# plot inputs vs outputs
pyplot.plot(inputs, outputs)
pyplot.show()

```

### Tanh hidden layer activation function

The Tanh function, also referred to as the hyperbolic tangent activation function, is remarkably close to the sigmoid activation function and even has the same S-shape.

The function accepts any real number as an input and outputs values between -1 and 1. The output value will be nearer to 1.0 the greater the input, or positive, and nearer to -1.0 the smaller the input, or negative.

This is how the Tanh activation function is calculated (Eq. 3).

$$\frac{e^x - e^{-x}}{(e^x + e^{-x})} \quad (3)$$

Where the natural logarithm's base,  $e$ , is a mathematical constant. With the help of the below-posted solved example, we may gain a general understanding of this function's form (Fig. 5).

When the example is run, the outputs are calculated for a variety of values, and an input-to-output graph is produced. It is possible to see Tanh's activation function's well-known S-shape (Fig. 6).

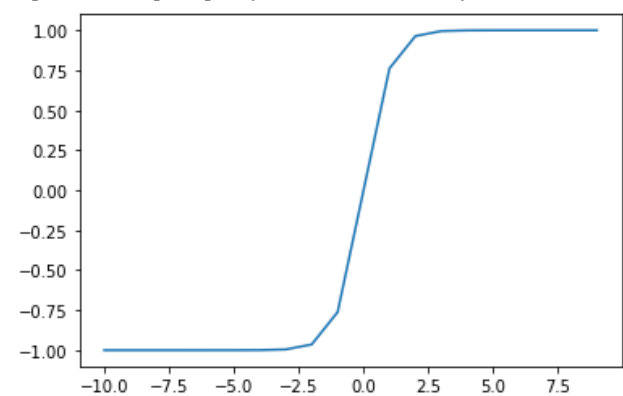
### How to choose a hidden layer activation function

The most unusual thing is to change the activation function across a network model; a neural network will usually always have the same activation function in all hidden layers.

In the 1990s, the sigmoid activation function was frequently used as the activation function. Then, between the mid-to-late 1990s and 2010, the Tanh function served as the standard activation function for hidden layers since it frequently outperforms the logistic Sigmoid.

**Figure 6**

Inputs vs. outputs plot for Tanh activation function.



On the other hand, the so-called leakage gradient problem caused by sigmoid functions like Tanh's can make the model more prone to issues during training.

In modern neural network models, the most prevalent architectures are MLP and CNN, which use the activation function or extensions of ReLU. In these neural networks, the default recommendation is to use the rectified linear unit, or ReLU. The activation function used in the hidden layers is chosen depending on the type of neural network architecture.

The Tanh or sigmoid activation functions, or possibly both, are still used in recurrent networks. For instance, the LSTM frequently employs Tanh activation for output and Sigmoid activation for recurrent connections.

Some examples of neural networks using the ReLU activation function.

- Multilayer perceptron (MLP): ReLU activation function.
- Convolutional neural network (CNN): ReLU activation function.

When you are not sure which activation function to use for your network, try a few and compare the results (Fig. 7).

### Activation for output layers

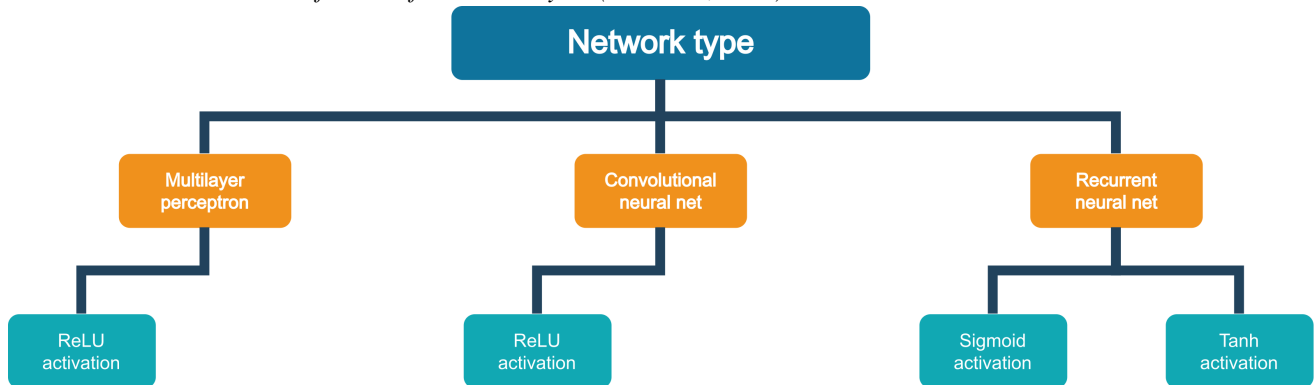
We know that all feed-forward neural network models have an output layer, which is the layer in a neural network model that directly generates a prediction.

There are other activation mechanisms; however, the three that are most frequently employed can be utilized in the output layer.

- Linear
- Logistic (Sigmoid)
- Softmax

**Figure 7**

*How to choose an activation function for hidden layers (Brownlee, 2021).*

**Figure 8**

*Example of the Linear activation function.*

```

# example plot for the linear activation function
from matplotlib import pyplot

# linear activation function
def linear(x):
    return x

# define input data
inputs = [x for x in range(-10, 10)]
# calculate outputs
outputs = [linear(x) for x in inputs]
# plot inputs vs outputs
pyplot.plot(inputs, outputs)
pyplot.show()
  
```

### ***Linear output activation function***

Because the activation function does not alter the weighted sum of the input in any way and instead returns the value straight, the linear activation function is also known as identity or no activation because it is like multiplying by 1.0.

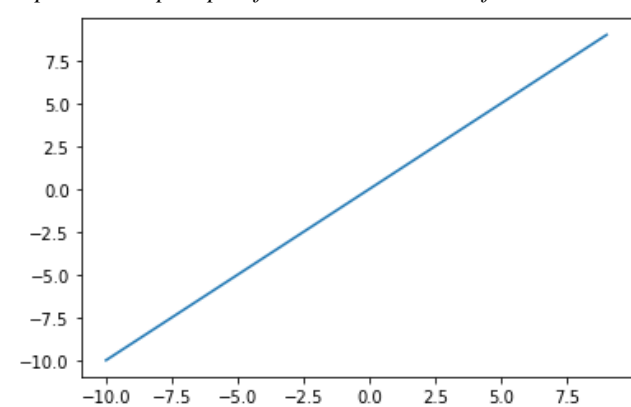
This function, also referred to as identity, enables the input and output to be equal, so if I apply a linear function to a multilayer neural network, it is considered to be a linear regression. Because the neural network to which the function is applied will only produce one value, this linear activation function is utilized when the output requires a linear regression.

With the help of the below-posted solved example, we may gain a general understanding of this function's form (Fig. 8).

When the example is run, the outputs are calculated for a range of values, and an input-to-output plot is produced.

**Figure 9**

*Inputs vs. outputs plot for Linear activation function.*



If the inputs and outputs are plotted against each other, a diagonal line will appear (Fig. 9).

### ***Sigmoid output activation function***

As was already discussed, the so-called leakage gradient problem might render the model more vulnerable to issues during training when using sigmoid functions like Tanh's.

The output of this function, also known as the logistic function, is understood as a probability because the range of possible output values is between zero and one. When a function is evaluated with extremely negative input values, such as  $x_0$ , it will result in a value of zero, 0.5 when evaluated at zero, and nearly 1 when evaluated at high values. As a result, the last layer uses this function to divide data into two categories.

The sigmoid function is currently underutilized because it is not centered, which has an impact on the neuron's capacity

**Figure 10**

Example of the Sigmoid activation function.

```

# example plot for the sigmoid activation function
from math import exp
from matplotlib import pyplot

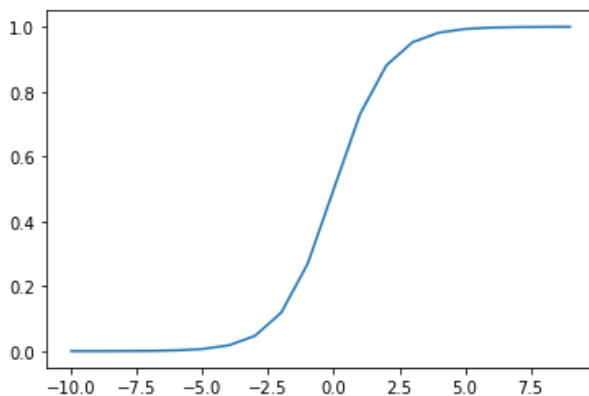
# sigmoid activation function
def sigmoid(x):
    return 1.0 / (1.0 + exp(-x))

# define input data
inputs = [x for x in range(-10, 10)]
# calculate outputs
outputs = [sigmoid(x) for x in inputs]
# plot inputs vs outputs
pyplot.plot(inputs, outputs)
pyplot.show()

```

**Figure 11**

Input vs. output plot for Sigmoid activation function.



for learning and training and, consequently, on the gradient disappearance issue.

To add some symmetry, we can study this function's form using the example that has been solved below (Fig. 10).

When the example is run, the outputs are calculated for a range of values, and an input-to-output plot is produced. It is possible to view the sigmoid activation function's well-known S-shape (Fig. 11).

A model with a sigmoid activation function in the output layer will be trained using target labels that are either 0 or 1.

### Softmax output activation function

The relationship to the argmax function is that it generates a 0 for all alternatives and a 1 for the selected option. The softmax function creates a vector of values that total to 1.0 that can be read as probability of class membership. A

"softer" variation of argmax called softmax enables an output that resembles the probability of a winner-take-all function.

As a result, the function accepts a vector of real numbers as input, and produces a vector of the same length that has probabilities represented by values that add to 1.0.

As seen below, the softmax function is computed (Eq. 4).

$$\frac{e^x}{\text{sum}(e^x)} \quad (4)$$

Where  $e$  is a mathematical constant that serves as the natural logarithm's basis and  $x$  is a vector of outputs.

This function is used to categorize data. For instance, if we are asked to identify the type of fruit from an image, applying softmax to the network will reveal the likelihood that the fruit is either 0.3 or 30% melon, 0.2 or 20% watermelon, or 0.5 or 50% papaya. The outcome will be the fruit with the highest probability, and it should be noted that the sum of these probabilities will be equal to 1. In other words, Softmax is utilized for determining probability for each class that is a part of many classes.

### How to choose an output activation function

The type of prediction problem being handled, more especially the kind of variable being predicted, should be considered when selecting the activation function for the output layer.

For instance, you can categorize prediction issues into two main groups: classification and regression. If the problem is a regression problem, you should use a linear activation function; however, there are three types of classification difficulties, so you can have a different function for each (Eq. 5).

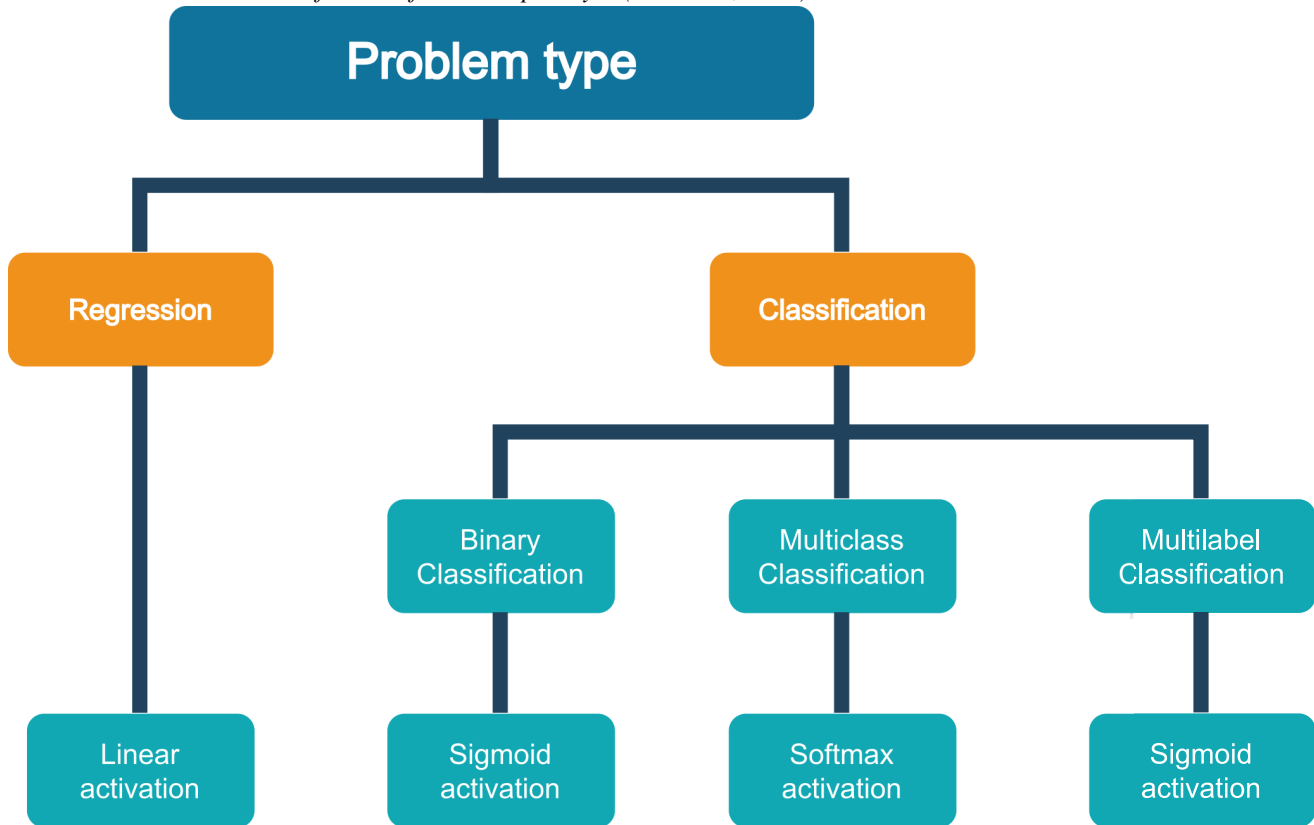
Regression = A node, i.e. a linear activation function (5)

Probability prediction is a classification problem, not a regression one. In each of these scenarios, your model will forecast the likelihood that an example belongs to each class, which you can then turn into a precise class label by rounding (for sigmoid) or argmax (for softmax).

- Binary classification: one node, sigmoid activation.
- Multi-class classification: one node per class, softmax activation.
- Multi-label classification: one node per class, sigmoid activation (Fig. 12).

**Figure 12**

*How to choose an activation function for the output layer (Brownlee, 2021).*



### Conclusion

In conclusion, choosing the right activation function is an important decision in the design of a neural network. The activation function plays a crucial role in the performance of the network and can greatly impact its ability to learn and generalize to new data. In this paper, we have explored the various activation functions that are commonly used in deep learning, including Sigmoid, Tanh, ReLU, and their variants.

Based on our analysis, it is clear that there is no one-size-fits-all activation function that is universally best for all tasks. Each activation function has its own strengths and weaknesses, and the optimal choice will depend on the specific characteristics of the data and the problem being solved.

In general, activation functions with a smooth, continuous curve, such as Sigmoid and Tanh, can help the network to converge faster and perform better. These functions are also well-suited for binary classification tasks. On the other hand, activation functions with a more complex or discontinuous curve, such as ReLU and its variants, can be more difficult to optimize but may be better suited for certain types of data or tasks. For example, ReLU and its variants are often used in

convolutional neural networks for image classification tasks, as they are able to introduce non-linearity and improve the network's ability to capture complex patterns in the data.

In terms of computational efficiency, activation functions that are more computationally efficient, such as ReLU and its variants, can speed up training and make it more efficient. These functions may be particularly useful for large-scale tasks where computational resources are limited.

It is also important to consider the vanishing gradient problem when selecting an activation function. Activation functions that have a slope that remains relatively large for a wide range of input values can help to mitigate the vanishing gradient problem and improve the network's ability to learn. On the other hand, activation functions that have a slope close to 0 for large input values can lead to the vanishing gradient problem and slow down convergence.

In summary, the choice of activation function is an important decision in the design of a neural network. By carefully evaluating the range and shape of the output, computational efficiency, ability to handle non-linearity, and the vanishing gradient problem, it is possible to select the best activation function for a given task. By considering the specific characteristics of the data and the problem being

solved, it is possible to choose an activation function that is well-suited to the task at hand and can help to improve the performance of the neural network.

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# Elastic shock experiments

*Experimentos de choque elástico*

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Elastic shock is a phenomenon that occurs when an object or material experiences a sudden and large deformation, followed by a rapid return to its original shape. This type of deformation is typically caused by a high-impact force or pressure, such as a collision or explosion. Elastic shock is a type of elastic deformation, which means that the material returns to its original shape once the external force is removed. Elastic shock is important in physics, engineering, and daily life because it affects the behavior and performance of materials and structures under load. In this paper, the results of some experiments on the elastic shock are presented.

*Keywords:* Deformation, elastic shock, experiments, force

El choque elástico es un fenómeno que se produce cuando un objeto o material experimenta una gran deformación repentina, seguida de un rápido retorno a su forma original. Este tipo de deformación suele deberse a una fuerza o presión de gran impacto, como una colisión o una explosión. El choque elástico es un tipo de deformación elástica, lo que significa que el material vuelve a su forma original una vez que se elimina la fuerza externa. El choque elástico es importante en la física, la ingeniería y la vida cotidiana porque afecta al comportamiento y las prestaciones de los materiales y las estructuras bajo carga. En este artículo se presentan los resultados de algunos experimentos sobre el choque elástico.

*Palabras clave:* Choque elástico, deformación, experimentos, fuerza

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## Introduction

As human beings, our social and intellectual development is primarily based on the supply of needs and problem solving (Logan & Goldberg, 1953). Problem solving, regardless of its nature, requires several processes and capabilities, among them: the abstraction of the world (as a mental operation) and its materialization (mathematically) (Falih & Shammari, 2019; Martínez et al., 2013).

With the help of the abstraction capacity, we separate the properties of an object and/or behavior through a mental operation, in order to understand its nature and the phenomena that govern it (Martínez & Acero, 2020). However, the purely mental abstraction of the world is not enough by itself, and the use of mathematical models is necessary, which allow the mental abstraction to be materialized in numbers (Martínez & Rendón, 2020). The combination of mental abstraction and mathematical modeling of phenomena is called physics.

One of the most important physical phenomena is collisions (Abdallah et al., 2019). From microscopic molecular collisions, such as the Kinetic Theory of Gases, based on the studies of Daniel Bernoulli, Ludwig Boltzmann and James Clerk Maxwell, to the Great Impact Theory, which postulates that, as a result of a collision between the young Earth and a protoplanet the size of Mars, the moon, the only natural satellite of the Earth, originated (Grozdanov et al., 2018). Collisions are present in many aspects and their study provides answers to a large number of events. In this article, an elastic collision between two bodies is analyzed, in order to abstract the nature of their behavior, and to prove that in an elastic motion the transfer of energy is complete.

## Methods

The mobiles to be studied in this case will be a pair of glass marbles (Fig. 1).

In collisions, there are three particular cases of interest:

- $m_1 = m_2$
- $m_1 \ll m_2$
- $m_1 \gg m_2$

To know which is our case, we will use Archimedes' principle of displacement, which states that the volume of the submerged body is equal to the volume of water displaced by it, being the volume, the quantification of the place occupied by an object in space (Fig. 2) (Resnick et al., 2005).

From the results we can make two statements:

- The marbles have the same volume.
- The marbles are made of the same material.

Since they meet the above statements, the marbles have the same mass, thus classifying our particular case of interest as (Eq. 1):

$$m_1 = m_2 \quad (1)$$

And in the interest of this exercise, we will assume that (Eq. 2):

$$m_1 = m_2 = 10 \text{ g} \quad (2)$$

An elastic collision is characterized by conservation of momentum as well as conservation of kinetic energy, that is why we are going to use a soapy plastic rail, in order to minimize friction between the surfaces and minimize losses (Fig. 3).

To analyze the collision behavior of these masses in the laboratory, we will record the digital video of the experiment in slow motion (Fig. 4). This guarantees accuracy in the motion analysis, which will be performed in the Tracker software (Martínez et al., 2022). Having a higher FPS (frames per second) translates into more data to analyze (Martínez et al., 2016).

## Video analysis

With the help of the simulation software Tracker - Video Analysis and Modeling Tool, one of the recorded videos of the experiment of two colliding mobiles will be analyzed. Tracker is free software that allows the analysis of movements (and other real situations) in one and two dimensions. The program allows us to extract in tables and graphs. The procedure is as follows:

1. We will proceed to load the video so that the simulator will be in charge of reconstructing the trajectory of the point to point collision of the mobiles.
2. The simulator requires the use of a calibration rod. The calibration rod (Fig. 5), will allow the software to abstract the dimensions of the place, playing its role as a measurement standard.
3. As in any other measurement, a coordinate system (Fig. 5) is needed to serve as a reference.

## Mathematical analysis

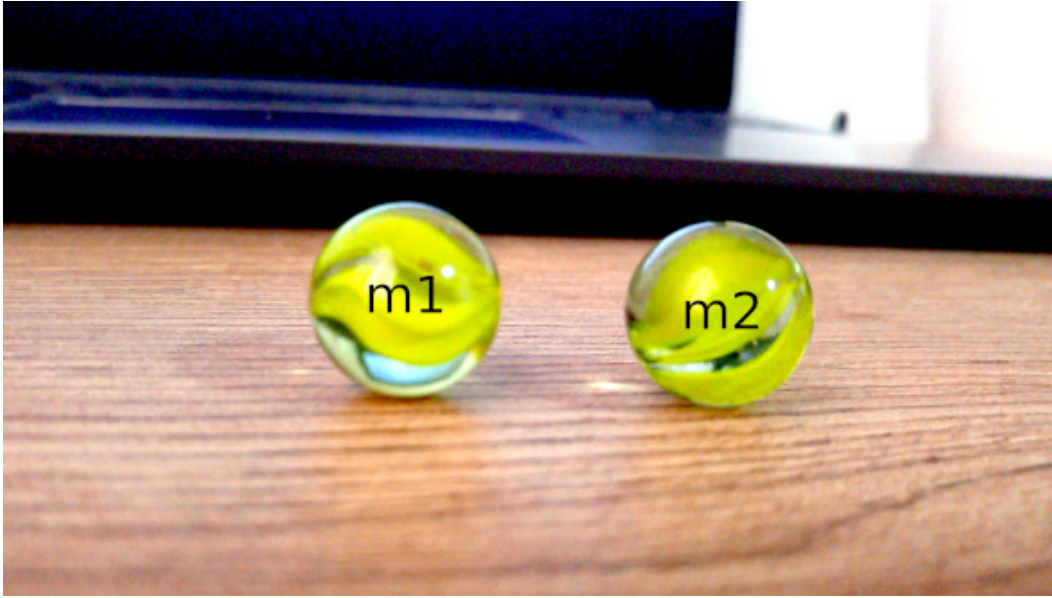
The results shown in Table 1 were generated for mass 1.

Using the data in Table 1, the curve is reconstructed by linear regression (Fig. 6). The resulting equation (Eq. 3) describes the trajectory recorded in the experiment for this mass.

$$x_{m1}(t) = -1.6 \times t + 0.12 \quad (3)$$

**Figure 1**

Mobiles: glass marbles.

**Table 1**

Data provided by Tracker software (black), linear momentum and kinetic energy of the collision calculated from Tracker data (red) for  $m_1$

Ball 1				
Time	Position	Speed	Linear momentum	Kinetic energy
$t$ [s]	$x$ [m]	$  \bar{v}   = \frac{\Delta x}{\Delta t} \left[ \frac{m}{s} \right]$	$p = m * v [kg * \frac{m}{s}]$	$E_c = \frac{m * v^2}{2} [J]$
0,016676195	0,094064725	0,000000000	0	0,0000
0,025014292	0,080523982	1,687174754	0,01687174754	0,0142
0,033352389	0,065929101	1,650885245	0,01650885245	0,0136
0,041690487	0,052993860	1,576362902	0,01576362902	0,0124
0,050028584	0,039641369	1,502741648	0,01502741648	0,0113
0,058366682	0,027934752	1,572151303	0,01572151303	0,0124
0,066704779	0,013424508	1,662549753	0,01662549753	0,0138
0,075042876	0,000000000	0,000000000	0	0,0000

Deriving this equation we obtain:

$$x_{m1}(t) = -1.6 \times t + 0.12 \text{ [m]} \quad (4)$$

$$v_x = \frac{dx_{m1}}{dt} = -1.6 \left[ \frac{m}{s} \right] \quad (5)$$

From Eq. 5, we calculate the magnitude of the velocity vector:

$$||v_x|| = \sqrt{v_x^2 + v_y^2} \quad (6)$$

$$||v_x|| = \sqrt{(-1.6)^2 + 0^2} = 1.6 \frac{m}{s} \quad (7)$$

Calculating the average of the instantaneous velocities provided by the software, we obtain:

$$\bar{v} = 1.608644268 \frac{m}{s} \quad (8)$$

Comparing the average value of the velocities with the value of the velocity obtained from the trajectory equation yields:

$$Error_{Experimental} = \frac{1.6 - 1.608644268}{1.6} = -0.5403\% \quad (9)$$

The results shown in Table 2 were generated for mass 2.

Using the data in Table 2, the curve is reconstructed by linear regression (Fig. 7). The resulting equation (Eq. 10) describes the trajectory recorded in the experiment for this mass.

$$x_{m2}(t) = -1.68 \times t + 0.117 \quad (10)$$

Deriving this equation we obtain:

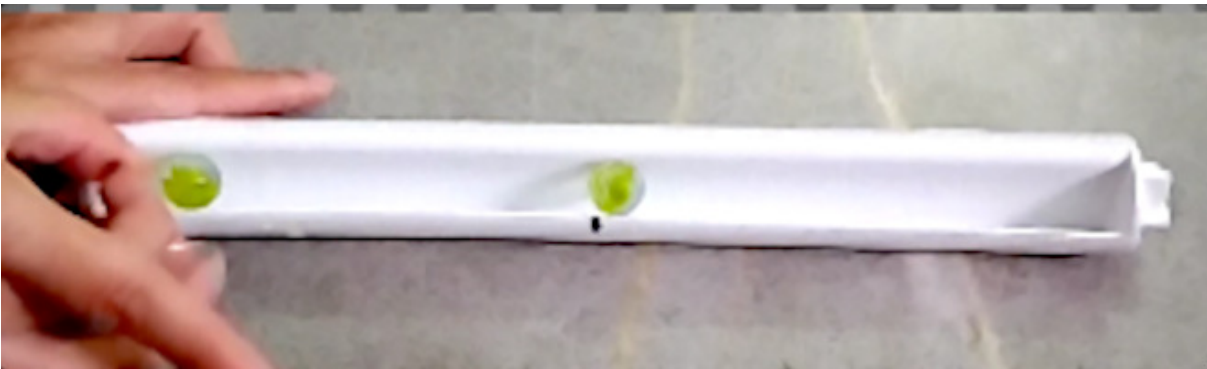
$$x_{m2}(t) = -1.68 \times t + 0.117 \text{ [m]} \quad (11)$$

**Figure 2**

Volume of the submerged body  $Vm_1 = Vm_2$ .

**Figure 3**

Soapy plastic rail.



$$v_x = \frac{dx_{m2}}{dt} = -1.68 \left[ \frac{\text{m}}{\text{s}} \right] \quad (12)$$

From Eq. 12, we calculate the magnitude of the velocity vector:

$$\|v_x\| = \sqrt{(-1.68)^2 + 0^2} = 1.68 \frac{\text{m}}{\text{s}} \quad (13)$$

Calculating the average of the instantaneous velocities provided by the software, we obtain:

$$\bar{v} = 1.58127 \frac{\text{m}}{\text{s}} \quad (14)$$

Comparing the average value of the velocities with the value of the velocity obtained from the trajectory equation yields:

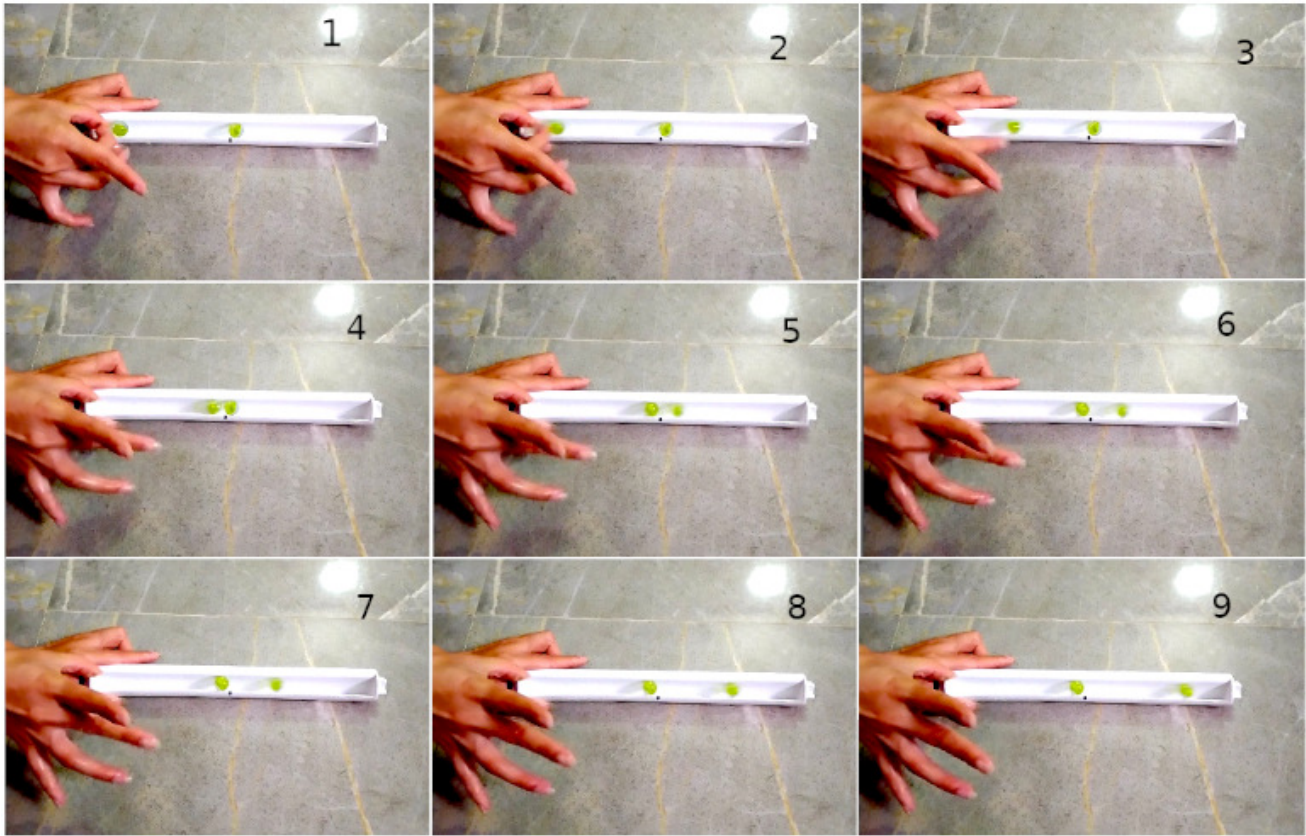
$$Error_{Experimental} = \frac{1.68 - 1.58127}{1.68} = 5.87655\% \quad (15)$$

#### Elastic collision

In an elastic collision it is observed that the mobiles have an intrinsic characteristic, due to the material from which they are made, they are rigid and non-deformable during the collision. Generally elastic collisions under ideal conditions are soundless, i.e. the kinetic energy is transferred during

**Figure 4**

Screenshots of the video under analysis.

**Table 2**

Data provided by Tracker software (black), linear momentum and kinetic energy of the collision calculated from Tracker data (red) for  $m_2$

Ball 2				
Time	Position	Speed	Linear momentum	Kinetic energy
$t$ [s]	$x$ [m]	$v = \frac{\Delta x}{\Delta t} \left[ \frac{m}{s} \right]$	$p = m * v$ [kg * $\frac{m}{s}$ ]	$E_c = \frac{1}{2} * m * v_i^2$ [J]
0,066705	0,000000	0,00000	0,00000	0,00000
0,075043	0,000000	1,662549753	0,01663	0,01382
0,083381	-0,026986	1,55904	0,01559	0,01215
0,091719	-0,039042	1,592786072	0,01593	0,01268
0,100057	-0,053548	1,59290	0,01593	0,01269
0,108395	-0,065604	1,55858	0,01559	0,01215
0,116733	-0,079539	1,58446	0,01584	0,01255
0,125071	-0,092027	1,49772	0,01498	0,01122
0,133410	-0,104514	1,60215	0,01602	0,01283
0,141748	-0,118744	0,00000	0,00000	0,00000

the collision and is not converted into sound or heat, and therefore the internal forces do not do any work.

Fig. 8 shows the result of the experiment. It is observed that under the condition  $m_1 = m_2$  there is a complete transfer of the quantity of motion. As a result, the mass  $m_1$  remains stationary in the place of  $m_2$ , and the mass  $m_2$  now moves. The collision occurs at 0.07504 second at the origin of the reference frame, which was chosen for convenience at the point of collision.

After the impact,  $m_1$  remains static, while the mass that was at rest,  $m_2$ , acquires a velocity equal to that of the first mass  $v_{fm1} = v_{im2}$  (Fig. 9). Thus, the linear momentum and kinetic energy are conserved (Eq. 16).

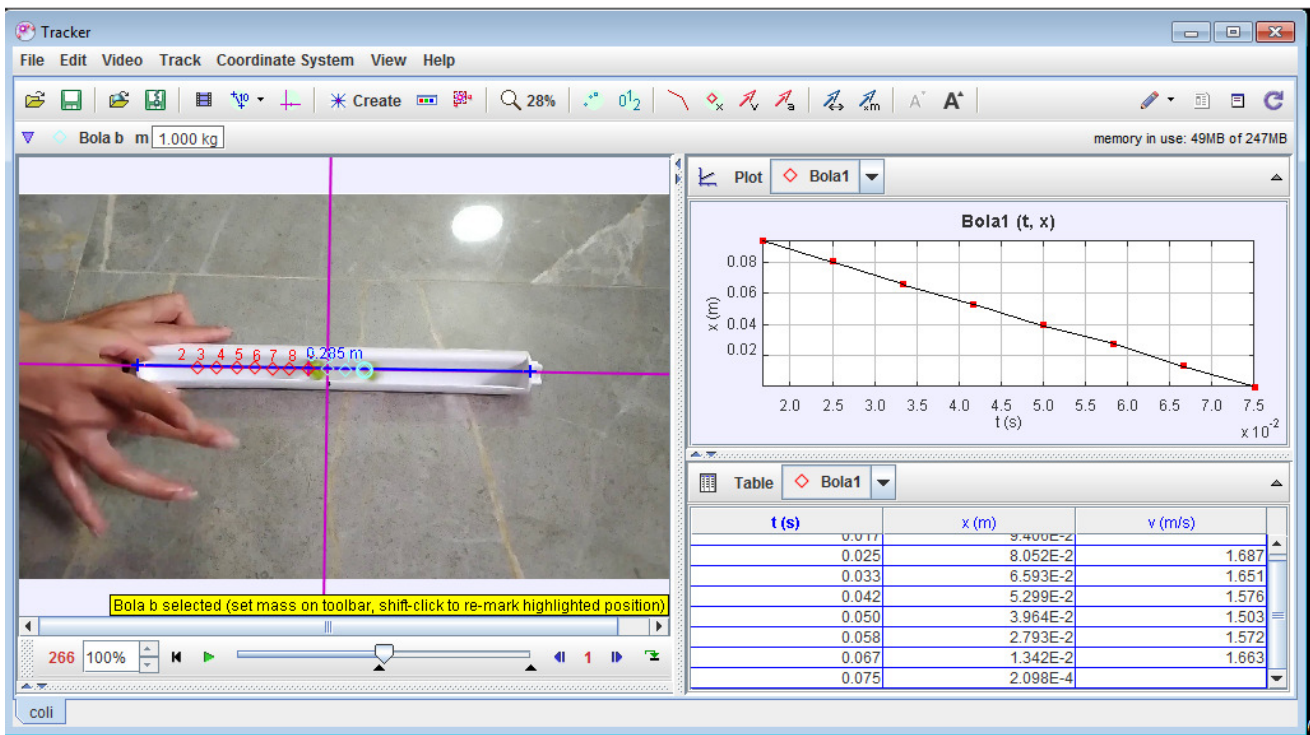
$$E_{kinetics\ m1} = E_{kinetics\ m2} \quad (16)$$

$$\frac{1}{2} m_1 V_i^2 = \frac{1}{2} m_2 V_i^2 \quad (17)$$

Despite fluctuations in the velocity values ranging from 1.5 to 1.69 m/s, they remain within this range, and although they should be constant all the time, the variation is not large

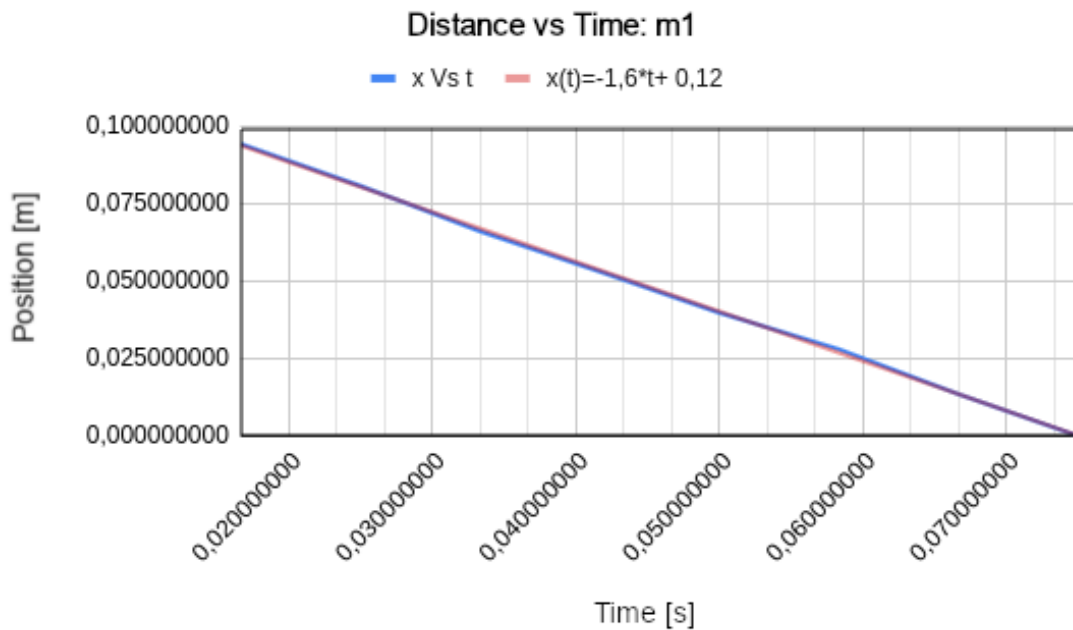
**Figure 5**

Tracker simulator: Collision analysis, measuring rod (blue line) and coordinate axis (purple axis).



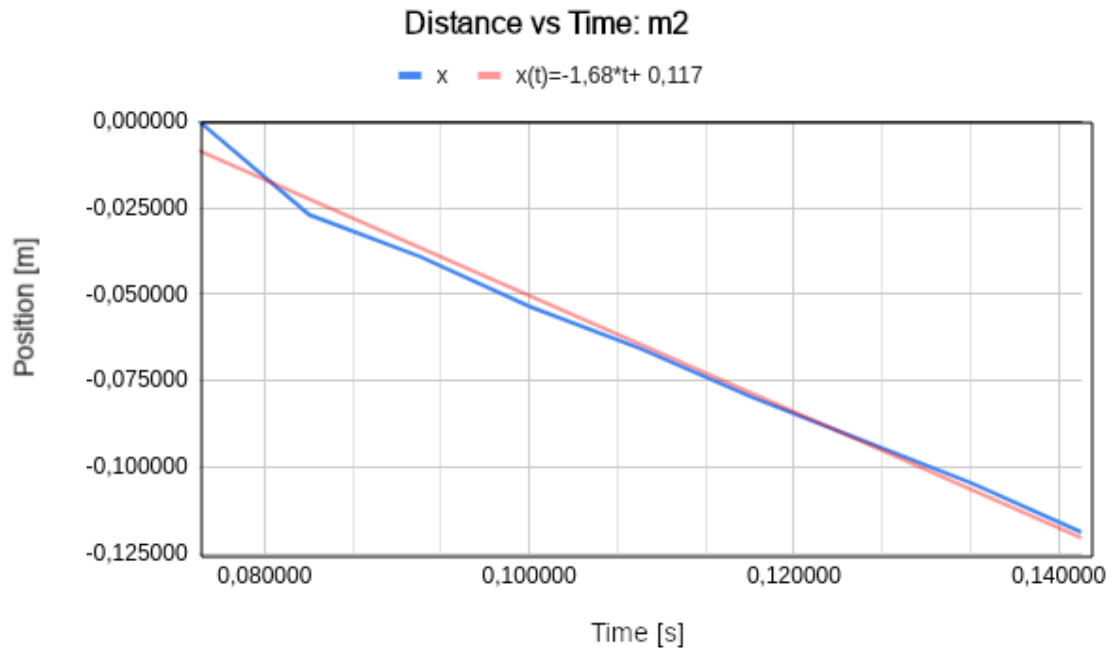
**Figure 6**

Plot of mass  $m_1$ , position versus time (blue tracker data). Linear regression of position versus time (pink).

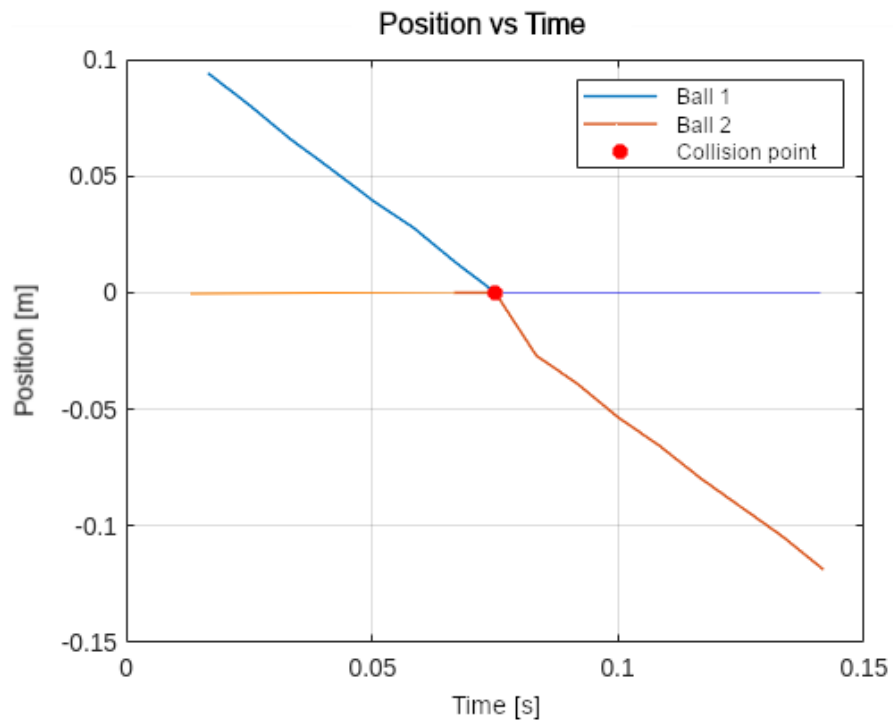


**Figure 7**

Plot of mass  $m_2$ , position versus time (blue tracker data). Linear regression of position versus time (pink).

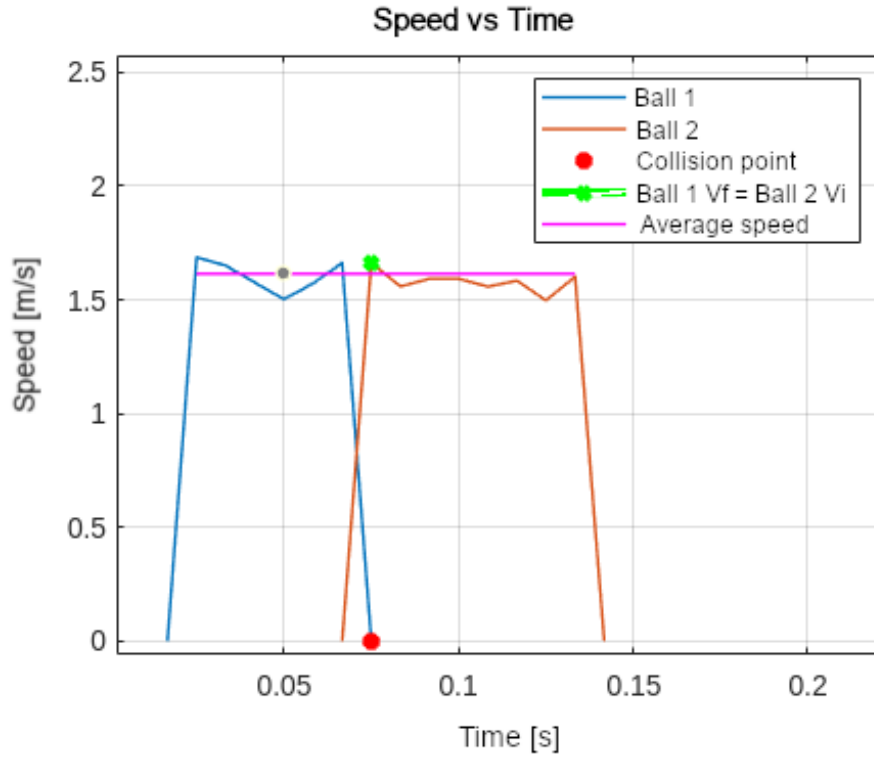
**Figure 8**

In the graphic:  $x_{m1}(t)$  (blue),  $x_{m2}(t)$  (orange), collision point (red).



**Figure 9**

Speeds  $v_{m1}$  and  $v_{m2}$  along the time.



enough to affect the nature of the collision. On average the velocity is  $v = 1.6149$  m/s (Fig. 9).

Table 3, and the corresponding Fig. 10, shows the behavior of the kinetic energy throughout the collision. The kinetic energy is not completely constant, but oscillates between the values of 0.011 J and 0.013 J, on average about 0.01274 J.

The amount of motion, momentum or linear momentum of the system, is also conserved as a consequence of all the forces involved in the collision are internal to the system of bodies (Eq. 18 and Fig. 11). On average the linear momentum along the collision is 0.0159 kg m/s, and oscillates between 0.015 and 0.016 kg m/s.

$$p_{m1} = p_{m2} \tag{18}$$

$$m_1 V = m_2 V \tag{19}$$

**Conclusion**

In this paper we document some experiments carried out in laboratory in a controlled manner to verify the properties of elastic collisions. In elastic collisions there is a complete

**Table 3**

*Collision kinetic energy calculated from Tracker data (red) for  $m_1$  and  $m_2$*

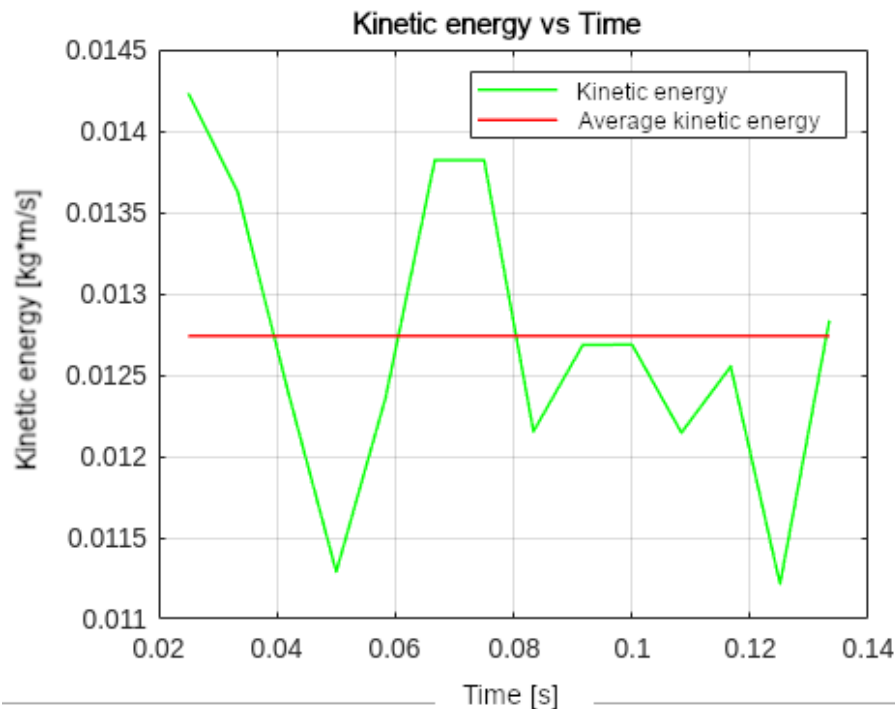
$m_1$	$m_1$	$m_2$	$m_2$
$t$ [s]	$E_c = \frac{1}{2} * m_1 * V_i^2$ [J]	$t$ [s]	$E_c = \frac{1}{2} * m_2 * V_i^2$ [J]
0,016676195	0,00000	0,066705	0,0000
0,025014292	0,014232	0,075043	0,0138
0,033352389	0,013627	0,083381	0,0122
0,041690487	0,012424	0,091719	0,0127
0,050028584	0,011291	0,100057	0,0127
0,058366682	0,012358	0,108395	0,0121
0,066704779	0,013820	0,116733	0,0126
0,075042876	0,000000	0,125071	0,0112
	0,000000	0,133410	0,0128
	0,000000	0,141748	0,0000

transfer of the amount of motion and the kinetic energy remains constant at all times. In order to corroborate this phenomenon, a setup consisting of two marbles and a rail with low friction was performed. The results were digitally recorded and analyzed to determine the characteristics of



**Figure 10**

Kinetic energy of both masses (green), and average kinetic energy over time (red).



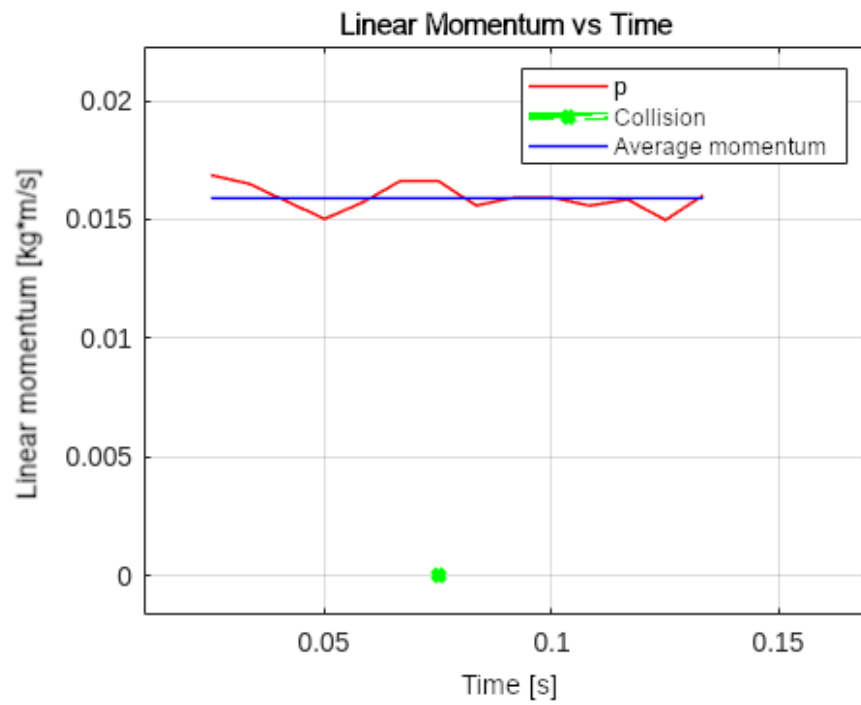
its behavior. In this work it was possible to demonstrate the characteristics of the phenomenon, with the normal variations attributable to non-ideal conditions. Although the physical variables such as the amount of motion and kinetic energy should be constant throughout the collision, the fluctuation they undergo is not significant enough to affect the nature of the elastic shock under study.

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**Figure 11**

Linear momentum or amount of motion along collision.



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# Instrucciones para los autores

## Tekhnê

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Facultad Tecnológica

### Alcance y política editorial de la revista

La revista **Tekhnê** es una revista institucional de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas (Colombia). Es arbitrada, y acepta trabajos originales en el campo de la ingeniería, la tecnología y las ciencias aplicadas, con la condición de que sean producto de trabajos de investigación. Desde su primer número en el año 2003, la revista ha mantenido su regularidad.

Posee un carácter científico-académico, y atiende a la comunidad nacional e internacional especialista en áreas de ingenierías eléctrica, electrónica, mecánica, de sistemas, industrial y civil. Publica resultados de investigación en inglés (artículos originales e inéditos), y está completamente abierta a especialistas de todo el mundo en calidad de autores y/o lectores. Es arbitrada mediante un proceso doble ciego, con rotación continua de árbitros.

La revista **Tekhnê** posee una periodicidad semestral, coincidente con los semestres académicos de la Universidad Distrital. La publicación se realiza los meses de junio y diciembre de cada año. El proceso de evaluación de los trabajos sometidos para la publicación contempla una etapa de aceptación inicial por parte del Comité Editorial, quien verifica el cumplimiento de los parámetros editoriales, y una evaluación por pares académicos mediante un proceso doble ciego. El tiempo que toma decidir sobre la aceptación de un trabajo nunca supera los seis (6) meses a partir de la fecha de recepción.

La revista **Tekhnê** está comprometida con altos estándares de ética y toma las medidas posibles para evitar las malas prácticas como el fraude y el plagio. Todos los autores deben declarar que sus manuscritos son originales, inéditos y de su autoría, condición necesaria para ser considerados por el Comité Editorial. La revista **Tekhnê** también se compromete a garantizar una justa, objetiva y rápida revisión de los manuscritos tanto por árbitros como por parte del Editor. Los autores

reconocen que han dado a conocer cualquier conflicto real o potencial de intereses con su trabajo o de beneficios parciales asociados a través de la cesión de derechos.

La revista **Tekhnê** es financiada por la Universidad Distrital Francisco José de Caldas, razón por la cual NO cobra por procesamiento y/o publicación de artículos (APCs).

### Tipos de artículos aceptados

La revista publica exclusivamente artículos de Investigación Científica y Tecnológica (según clasificación del Índice Nacional de Publicaciones Científicas y Tecnológicas Publindex de Colciencias), los cuales se caracterizan por presentar resultados originales de proyectos terminados de investigación, con secciones claramente diferenciadas de introducción, metodología, resultados y conclusiones. Otro tipo de artículos como los denominados de reflexión, revisión, artículos cortos o reportes de casos no son aceptados, y serán rechazados por el Comité Editorial sin surtir proceso alguno de evaluación.

### Formato del manuscrito

En cuanto a estructura, deben ser evidentes las secciones de introducción, metodología, resultados, conclusiones y referencias. El resto del documento se debe conformar en concordancia con su contenido. La longitud no debe superar las 25 páginas en su totalidad. En la parte inicial de la primera página se debe incluir: (1) Un título del manuscrito (en español e inglés), corto, descriptivo del contenido y atractivo para el lector. (2) Nombre completo de los autores y detalles de afiliación institucional, incluido correo electrónico. (3) Resumen (en español e inglés) del manuscrito con un tamaño máximo de 250 palabras, que establezca el objetivo, la metodología, los resultados y principales conclusiones. (4) Palabras claves, máximo cinco, en minúsculas y separadas por comas.

En cuanto al formato de documento solicitado a los autores, se pide utilizar LaTeX de acuerdo con la plantilla disponible en el portal web de la revista. No se debe modificar el formato de la plantilla. Las tablas y figuras deben ser claras y nítidas, insertadas como archivos EPS con la mayor calidad posible. Se pide que estas figuras sean remitidas en un archivo comprimido por separado. Si se usan líneas o figuras en colores, no se debe usar colores claros (amarillos, celestes y similares). El Editor se reserva el derecho de eliminar toda figura o tabla que no cumpla las normas. Toda figura, tabla, ecuación o referencia incluida en el manuscrito debe estar referenciada/citada en el cuerpo del documento. Las referencias deben manejar correcto estilo APA sexta edición. No se deben utilizar notas al pie de página, y usar máximo tres niveles para los títulos. Se puede incluir una sección de Agradecimientos (altamente recomendada), redactada en forma sobria, de no más de cuatro líneas justo después de las Conclusiones.

Se deben remitir todos los archivos fuente. Para todos los casos, los autores deben remitir, junto con las imágenes, un archivo BibTeX (un único archivo \*.bib) con todas las referencias utilizadas en el artículo, cada referencia con una key única. Este archivo puede ser generado desde manejadores de referencias como Mendeley y Zotero, o generado con herramientas como JabRef.

En cuanto al lenguaje y estilo de redacción, se deben utilizar oraciones simples y evitar regionalismos. Se debe poner especial cuidado en el

correcto uso de la ortografía y redacción, de acuerdo a las reglas del lenguaje.

### Formato de publicación

Los manuscritos son publicados siguiendo el estilo APA sexta edición. Esto es realizado en la diagramación, y es transparente para los autores.

### Cambios en la edición

El Editor se reserva el derecho, y así lo acepta el(la)(los) autor(a)(es) con el sólo envío del manuscrito, de realizar modificaciones con el objeto de lograr una mejor presentación e impacto del trabajo. Estas modificaciones pueden incluir cambios en el título, resumen, palabras clave, figuras, tablas y texto, entre otros, cambios que no afectan, según el Editor, la esencia del trabajo enviado por los autores. En particular, figuras que no pueden ser bien reproducidas pueden ser eliminadas por el Editor. Las referencias incompletas serán también eliminadas por exigencias de las bases de datos.

### Envío de manuscritos

Los autores deben enviar sus artículos a través de la aplicación para tal fin del Open Journal System (<http://revistas.udistrital.edu.co/ojs/index.php/tekhne/index>) en formato digital, adjuntando:

- La carta de presentación.
- La carta de cesión de derechos (según formato).

La carta de presentación debe estar dirigida al director y editor de la revista, Ing. Fredy H. Martínez S., y debe incluir:

- Solicitud expresa de considerar el artículo para publicarlo en la revista **Tekhnê**.
- Título completo del trabajo.
- Nombres completos de todos los autores, con detalle de entidad a la que se encuentran vinculados, dirección e-mail institucional, títulos académicos, ciudad y país.
- Certificación de la originalidad y el carácter inédito del artículo.
- Exclusividad de su remisión a la revista **Tekhnê**.
- Confirmación de la autoría con la firma de todos los autores.
- Institución que financió o avaló el proyecto.

El proceso de envío consta de tres etapas:

1. Envío del artículo en formato PDF. Se carga al OJS un único archivo sin comprimir.
2. Registro de los datos. Se registra en el OJS los datos básicos de los autores y del artículo.
3. Envío de Archivos Complementarios. Todos los archivos complementarios se envían en un único archivo comprimido. Estos archivos complementarios incluyen: los archivos fuente del documento, tanto texto como imágenes en alta calidad, archivo BibTeX con todas las referencias utilizadas, la carta de presentación, y la carta de cesión de derechos.

### Proceso de publicación

El proceso que sigue la revista para la evaluación y publicación de trabajos es el siguiente:

- Recepción del manuscrito (primera versión, convocatoria permanente)
- Verificación de normas por parte de auxiliar de la revista
- Notificación a autores de recepción, solicitud de ajustes de forma y de diligenciamiento de formato de datos de autores
- Recepción de manuscrito (segunda versión) y formato de datos de autores
- Revisión por parte del Comité Editorial
- Notificación a autores de si el manuscrito entra o no a evaluación por parte de pares
- Envío de manuscrito a pares seleccionados
- Recepción de evaluación de pares
- Notificación de evaluación a autores, y solicitud de correcciones si son pertinentes
- Recepción de manuscrito (tercera versión)
- Estudio de manuscrito corregido por parte del Comité Editorial
- Notificación a autores de decisión final de publicación y solicitud de carta de cesión de derechos
- Recepción de carta de cesión de derechos
- Corrección de estilo y diagramación del manuscrito
- Envío de versión final a autores para verificación de errores y aprobación final
- Publicación del artículo
- Notificación a autores de publicación
- Entrega de ejemplares a autores

### Contacto

Para cualquier solicitud de información adicional puede comunicarse con:

#### Prof. Fredy H. Martínez S.

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# Instructions for authors

# T e k h n ê

Tecnología al servicio de la sociedad  
Universidad Distrital Francisco José de Caldas - Facultad Tecnológica

Tekhnê Journal  
Universidad Distrital Francisco José de Caldas  
Facultad Tecnológica

## Scope and editorial policy of the journal

The **Tekhnê** journal is an institutional journal of the Technological Faculty of District University Francisco José de Caldas (Colombia). It is arbitrated, and accepts original articles in the field of engineering, technology and applied sciences on the condition that they are the product of research work. Since its first issue in 2003 the journal has maintained its regularity.

It has a scientific-academic nature and attends the specialist national and international community in the areas of electrical, electronics, mechanical, systems, industrial and civil engineering. Publishes research results in English (original and unpublished articles), and is fully open to experts from around the world as authors and/or readers. It is arbitrated by a double-blind process, with continuous rotation of evaluators.

The **Tekhnê** journal has twice a year periodicity, coinciding with the academic semesters of the District University. The publication is made in June and December each year. The evaluation process of the papers submitted for publication includes a stage of initial acceptance by the Editorial Committee, which verifies compliance with the editorial parameters and an evaluation by academic peers through a double blind process. The time taken to decide on the acceptance of a paper never exceeds six (6) months from the date of receipt.

The **Tekhnê** journal is committed to high ethical standards and take possible measures to avoid bad practices such as fraud and plagiarism. All authors must declare that their manuscripts are original, unpublished and of his own, needed condition to be considered by the Editorial Committee. The **Tekhnê** journal also is committed to ensuring a fair, objective and quick review of manuscripts both referees as by the Editor. The authors recognize that they have disclosed any actual or potential conflict of interest with their work or partial benefits associated through the transfer of rights.

The **Tekhnê** journal is funded by the District University Francisco José de Caldas, which is why it does NOT charge for processing and/or publishing articles (APCs).

## Types of articles accepted

The journal publishes only Scientific and Technological Research articles (as classified by Publindex, the National Abstracting and Indexing System for Serial Publications in Science, Technology and Innovation of Colciencias), which are characterized by original results of completed research projects with clearly distinct sections of introduction, methodology, results and conclusions. Other articles as called reflection, review, short articles or case reports are not accepted and will be rejected by the Editorial Committee without dispensing any evaluation process.

## Manuscript format

Regarding the structure, should be evident the sections of introduction, methodology, results, conclusions and references. The rest of the document must conform in accordance with its contents. The length should not exceed 25 pages in full. In the initial part of the first page should include: (1) A manuscript title (in Spanish and English), short, descriptive of the content and attractive to the reader. (2) Full name of the authors and institutional affiliation details, including email. (3) Abstract (in Spanish and English) of the manuscript with a maximum size of 250 words, which set the objective, methodology, results and major conclusions. (4) Keywords, up to five, lowercase and separated by commas.

Regarding the document format requested by authors, it is requested to use LaTeX according to the template available in the journal's web portal. The format of the template should not be modified. Tables and figures should be clear and sharp, inserted as EPS files with the highest possible quality. It is requested that these figures be submitted in a separate compressed file. If colored lines or figures are used, light colors (yellow, light blue, and similar) should not be used. The Editor reserves the right to delete any figure or table that does not comply with the rules. Any figure, table, equation, or reference included in the manuscript must be referenced/cited in the body of the paper. References must use the correct APA sixth edition style. Footnotes should not be used, and a maximum of three levels should be used for headings. An Acknowledgements section may be included (highly recommended), written soberly, of no more than four lines just after the Conclusions.

All source files must be submitted. In all cases, authors should submit, together with the images, a BibTeX file (a single \*.bib file) with all the references used in the article, each reference with a unique key. This file can be generated from reference managers such as Mendeley and Zotero, or generated with tools such as JabRef.

Regarding the language and style of writing, the author must use simple sentences and avoid regionalisms. He must take special care to use the correct spelling and writing, according to the rules of language.

## Publication format

The manuscripts are published following the APA style 6th edition. This is done in the layout, and is transparent to the authors.

### Editing changes

The Editor reserves the right, and is accepted by the author(s) with the only article shipping, to make changes in order to achieve a better presentation and impact of the work. These modifications may include changes in the title, abstract, keywords, figures, tables and text, among others, changes that do not affect, according to the Editor, the essence of the work submitted by the authors. In particular, figures that can not be well reproduced can be eliminated by the Editor. Incomplete references will also be eliminated by demands of databases.

### Sending manuscripts

Authors must submit their articles through the application for the purpose of the Open Journal System (<http://revistas.udistrital.edu.co/ojs/index.php/tekhne/index>) in digital format, attaching:

- The presentation letter.
- The transfer of rights letter (according to format).

The presentation letter should be addressed to the director and editor of the journal Prof. Fredy H. Martínez S., and it should include:

- Express request to consider the article for publication in **Tekhnê** journal.
- Full title of the article.
- Full names of all authors, detailing entity linked, institutional e-mail address, academic degrees, city and country.
- Certification of the originality and novelty of the article.
- Exclusivity of submission to **Tekhnê** journal.
- Confirmation of authorship with the signature of all authors.
- Institution financing the project.

The submission process consists of three stages:

1. Sending the article in PDF format. OJS is charged with a single uncompressed file.
2. Data recording. the basic data of the authors and article are registered in the OJS.
3. Complementary files. All additional files are sent in a single compressed file. These complementary files include: the source of the document, both text and images in high quality, BibTeX file with all references used, the presentation letter, and the transfer of rights letter.

### Publishing process

The process followed by the journal for evaluation and publication of articles is as follows:

- Receipt of the manuscript (first version, continuously open call)
- Verification of standards by the assistant of the journal
- Notification to authors of receipt, request for the form adjustments and filling of authors data format
- Receipt of the manuscript (second version) and authors data format
- Review by the Editorial Committee
- Notification to authors if the manuscript is sent or not to evaluation by peers
- Sending the manuscript to selected peers
- Reception peer evaluation

- Notification of evaluation to authors, and request corrections if they are relevant
- Receipt of the manuscript (third version)
- Study of manuscript corrected by the Editorial Committee
- Notification to authors of publication and final decision, and request the rights transfer letter
- Reception of the rights transfer letter
- Style correction and layout of the manuscript
- Send final version to authors for error checking and final approval
- Publication of the article
- Notification to authors of the publication
- Delivery of copies to authors

### Contact

For any request for additional information please contact:

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