INTRODUÇÃO À INVESTIGAÇÃO

MEFT – 5º ANO

Filipe Rafael Joaquim (CFTP-DFIST)

DF
DEPARTAMENTO
DE FÍSICA
TÉCNICO LISBOA

OBJECTIVES

CALL YOUR ATTENTION TO SOME ASPECTS WHICH ARE IMPORTANT WHEN DOING RESEARCH (AND NOT ONLY)

"DOs" & "DON'TS"

To some of you many things will probably look like obvious…
but believe me… you make obvious mistakes

- GET USED TO "SCIENTIFIC LANGUAGE"
- CREATE THE HABBIT OF TALKING ABOUT SCIENCE
- ENRICH YOUR SCIENTIFIC CULTURE

STRUCTURE

CLASSES

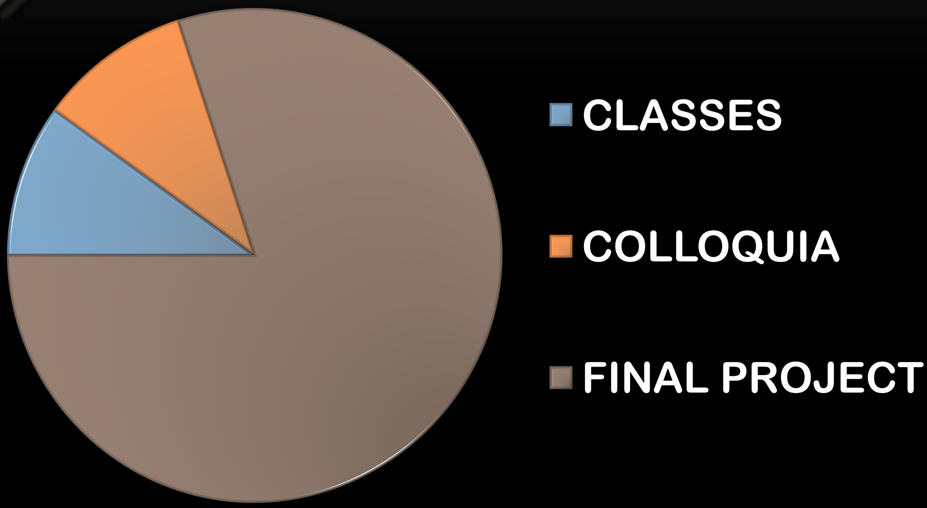
- Classes given by me.
- Presentations from colleagues of the previous semester
- Your presentations (4/class)

COLLOQUIA

Topics from several scientific areas: Particle and Nuclear Physics, Plasma Physics, Cosmology, Astrophysics, Neuro-science, Geophysics, …

There is a calendar for the colloquia in the Physics Department webpage. You will also receive emails announcing the colloquia.

EVALUATION



$$N_F = N_A + N_C + N_T$$
$$= 2{*}\%_{AA} + 2{*}\%_{CA} + 0.8\ N_{TF}$$

N_F - final grade

$\%_{AA}$ - % of attended classes

(only those in which projects are presented)

$\%_{CA}$ - % attended colloquia

N_{TF} - Final project grade (0-20)

Approval conditions: $\%_{AA} >= 0.5$ & $\%_{CA} >= 0.5$ & $N_T >= 8.0$

Final project grade (N_T):

Article + (Work + final presentation)

EVALUATION

THERE WILL BE PRESENCE SHEET ONLY ON THOSE CLASSES IN WHICH STUDENTS PRESENT THEIR PROJECTS

THERE WILL BE PRESENCE SHEETS IN ALL COLLOQUIA

DON'T FORGET TO SIGN (FIRST AND LAST NAME). YOU WILL NOT BE ALLOWED TO SIGN AFTERWARDS.

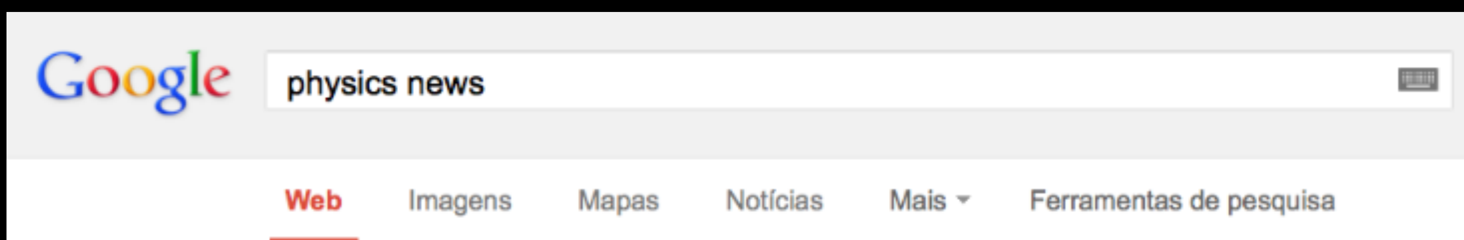
AND YOU SHOULD ATTEND THE WHOLE COLLOQUIUM

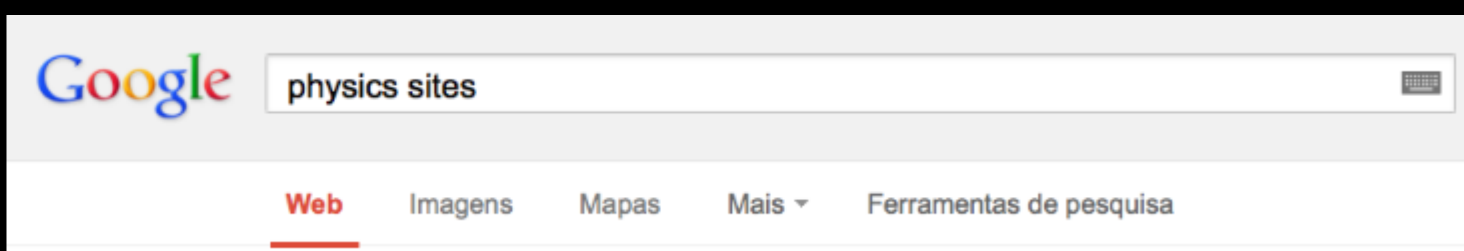
FINAL PROJECT Where to look for?

The final project is about a topic of your choice, but…

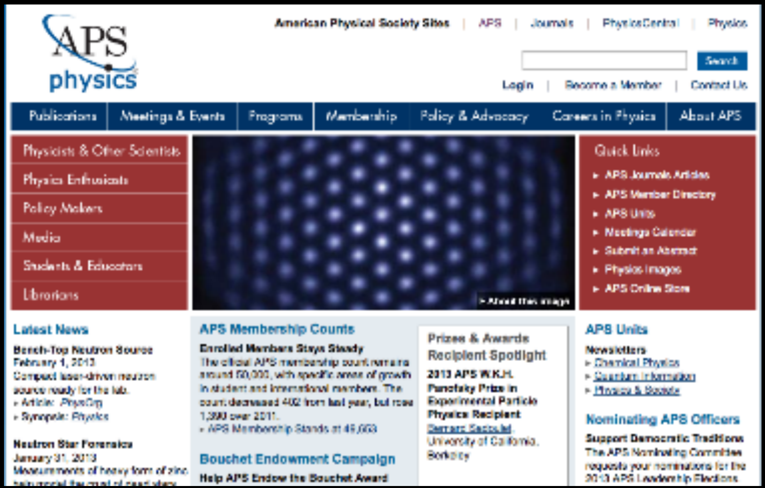
IT CANNOT BE RELATED WITH YOUR MASTER THESIS TOPIC

WHERE TO LOOK FOR A TOPIC?

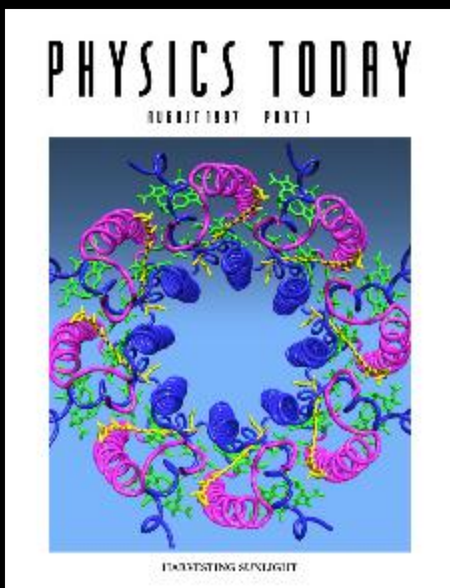


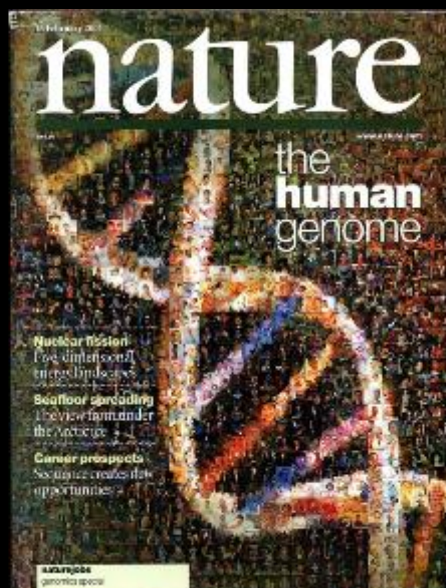


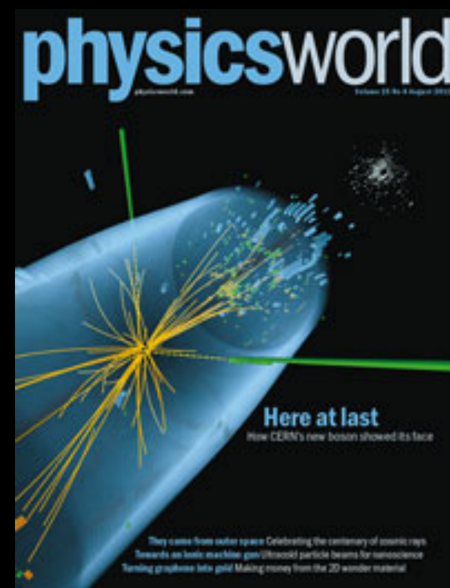
FINAL PROJECT Where to look for?



FINAL PROJECT Where to look for?







FINAL PROJECT Where to look for?

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Subject search and browse: Physics Search Form Interface Catchup

29 Aug 2012: Simons Foundation funds new arXiv sustainability model

See cumulative "What's New" pages. Read robots beware before attempting any automated download

Physics

- Astrophysics (**astro-ph** new, recent, find)
  includes: Cosmology and Extragalactic Astrophysics; Earth and Planetary Astrophysics; Galaxy Astrophysics; High Energy Astrophysical Phenomena; Instrumentation and Methods for Astrophysics; Solar and Stellar Astrophysics
- Condensed Matter (**cond-mat** new, recent, find)
  includes: Disordered Systems and Neural Networks; Materials Science; Mesoscale and Nanoscale Physics; Other Condensed Matter; Quantum Gases; Soft Condensed Matter; Statistical Mechanics; Strongly Correlated Electrons; Superconductivity
- General Relativity and Quantum Cosmology (**gr-qc** new, recent, find)
- High Energy Physics - Experiment (**hep-ex** new, recent, find)
- High Energy Physics - Lattice (**hep-lat** new, recent, find)
- High Energy Physics - Phenomenology (**hep-ph** new, recent, find)
- High Energy Physics - Theory (**hep-th** new, recent, find)
- Mathematical Physics (**math-ph** new, recent, find)
- Nonlinear Sciences (**nlin** new, recent, find)
  includes: Adaptation and Self-Organizing Systems; Cellular Automata and Lattice Gases; Chaotic Dynamics; Exactly Solvable and Integrable Systems; Pattern Formation and Solitons
- Nuclear Experiment (**nucl-ex** new, recent, find)
- Nuclear Theory (**nucl-th** new, recent, find)
- Physics (**physics** new, recent, find)
  includes: Accelerator Physics; Atmospheric and Oceanic Physics; Atomic Physics; Atomic and Molecular Clusters; Biological Physics; Chemical Physics; Classical Physics; Computational Physics; Data Analysis, Statistics and Probability; Fluid Dynamics; General Physics; Geophysics; History and Philosophy of Physics; Instrumentation and Detectors; Medical Physics; Optics; Physics Education; Physics and Society; Plasma Physics; Popular Physics; Space Physics

www.cornell.edu Physics (**quant-ph** new, recent, find)

SOME EXAMPLES FROM PREVIOUS SEMESTER

- Quantum mechanics and photosynthesis
- Soniphication
- Stirling engine
- Coin-launching machine
- Cancer cell evolution model
- Statistical model for Language evolution
- Stochastic models in Physics and Finance
- Chladni figures
- Coiling of viscuos liquids
- Electromagnetic fields in GR
- Music as a complex network
- Predicting Liga NOS match outcome

COMMUNICATION

THERE IS NO SCIENCE WITHOUR COMMUNICATION

FINAL PROJECT Components

WRITTEN - ARTICLE

SEND TO: filipe.joaquim@tecnico.ulisboa.pt

UNTIL 72H BEFORE YOUR PRESENTATION

(máx. 4 pages, double column, revtex 4.1)

Penalization of 0.5 in the final project grade if you send between 72 and 48h before the presentation

Penalization of 1.0 in the final project grade if you send within 48h before the presentation

ORAL - PRESENTATION

MAX DURATION: 20 min + 10 min discussion

You should **ALL** participate in the discussion!

ARTICLE

“SCIENTIFIC” ARTICLE

Coiling of Viscous Liquids

Fábio Cruz (n.69476)[1]

[1] *Departamento de Física, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*

A thin “rope” of viscous fluid falling from high enough coils upon contact with a rigid surface. This coiling is controlled by the balance between the three main forces acting on the fluid: viscous, gravitational and inertial forces. We introduce the key aspects of the theoretical framework used to describe slender viscous jets, and compare the scaling laws governing the gravitational and inertial coiling regimes with experimental data. Despite limitations of the experimental setup, we find good agreement with theoretically predicted trends.

I. INTRODUCTION

A stream of viscous fluid falling from a sufficient height approaches a surface in the form of a rotating coil. The simplest example of such behaviour, usually called “liquid rope coiling”, can be observed when pouring a thin stream of honey onto a toast. This phenomenon is an example of a buckling instability, in which a fluid becomes unstable by bending due to an axial compressive stress. Other examples of buckling instabilities are the periodic folding/coiling of lava streams [1] and the jet filling of containers [2], with applications in geophysics and food processing, respectively.

Although fluid coiling has been studied for over 50 years [3][4], only recently the mechanisms that determine the behaviour of these systems have been explored with greater depth. In 2004, Ribe [5] proposed that the dynamics of a thin stream of viscous fluid are determined by the relative magnitudes of viscous, gravitational and inertial forces. Moreover, he demonstrated numerically the existence of three coiling regimes, depending on the fall height and flow rate.

In this work we present a compact introduction to the theoretical framework used to describe coiling liquid ropes[1] (section II) and compare the force-balance predictions for the coiling frequency with results obtained in a homemade experiment (sections III-IV).

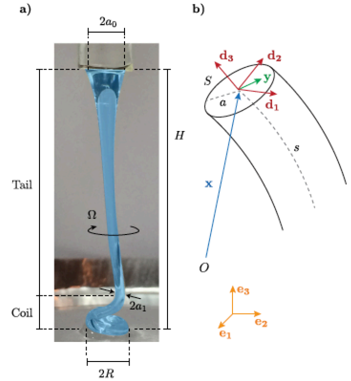


FIG. 1: a) Main parameters used to describe the coiling of viscous liquids; b) Geometry considered in the slender jet approximation (modified from [5]).

II. THEORETICAL FRAMEWORK

Our objective in the following text is to illustrate the guidelines to derive the dependence of the coiling frequency Ω on the fluid's fall height H and flux rate Q (see Fig. 1 a)). The flux is considered to be constant and injected from a circular hole of radius a_0. The liquid is characterized by its density ρ and kinematic viscosity ν. The rotating liquid column consists of a long, almost vertical tail and a coil next to the surface, of radius R. During the fall, the jet's radius decreases due to gravity stretching, such that at the coil its value is $a_1 < a_0$.

By exploiting the jet's slenderness (i.e., the fact that the typical length scale for the variations of the flow variables is much larger than the jet's radius), we can describe the dynamics of this system as those of a curved line. We choose this line to be the jet's axis, parametrised by the coordinate $s \in [0, \ell]$, where $s = 0, \ell$ represent the points of injection and contact with the surface, respectively. For each point s, three orthogonal vectors $\mathbf{d}_\alpha$ are defined, where $\mathbf{d_3}$ is perpendicular to the circular jet's cross section plane and $\mathbf{d_{1,2}}$ are arbitrary vectors in this plane (see Fig. 1 b)). Any fluid element lying on the jet's cross section S is described by the coordinates $\mathbf{r} = \mathbf{x} + \mathbf{y}$ in the laboratory coordinate system $\mathbf{e}_\alpha$, where $\mathbf{x}$ is the jet's axis position and $\mathbf{y} = y_1\mathbf{d_1} + y_2\mathbf{d_2}$ is the position of the fluid element relative to it.

To derive the equations for the global force and torque balances on the jet, we need to integrate the Navier-Stokes equation across the jet's cross section. The important dynamical quantities arising in this integration are the stress vector $\mathbf{N}$ and the bending/twisting moment vector $\mathbf{M}$, defined by

$$\mathbf{N} \equiv N_\alpha \mathbf{d}_\alpha = \int_S \boldsymbol{\sigma}\, \mathrm{d}S\,, \tag{1a}$$

$$\mathbf{M} \equiv M_\alpha \mathbf{d}_\alpha = \int_S \mathbf{y} \times \boldsymbol{\sigma}\, \mathrm{d}S\,, \tag{1b}$$

where $\boldsymbol{\sigma}$ is the stress vector acting on the fluid elements, in which the viscous behaviour is embedded. The components N_α and M_α represent the fluid's resistance to stretching and bending/twisting, respectively.

The integrated force balance equation is

$$\rho A[\boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{x}) + 2\boldsymbol{\Omega} \times \mathbf{U} + U\mathbf{U}'] = \mathbf{N}' + \rho A \mathbf{g}, \tag{2}$$

where $A = \pi a^2$ is the area of the jet's cross section, $\boldsymbol{\Omega} = \Omega\mathbf{e_3}$ is the coiling angular speed vector, $\mathbf{U} = U\mathbf{d_3}$ is the fluid axial velocity and $\mathbf{g} = -g\mathbf{e_3}$ is the gravitational acceleration. The three terms on the left-hand side of this equation represent the centrifugal and Coriolis forces and the axial acceleration, respectively. These inertial terms are balanced by the two terms on the right-hand side, which represent the jet's viscous resistance to deformation and gravitational effects. The derivatives present in this equation (and others that follow) are in respect to s.

The resultant torque balance equation is

$$0 = \mathbf{M}' + \mathbf{d_3} \times \mathbf{N}\,, \tag{3}$$

where the angular acceleration and the gravity-induced torque were neglected by considering the jet is slender.

As stated before, it is the competition between viscous, gravitational and inertial forces at the coil that determines the dynamics of the jet. To estimate the different forces acting on the jet at this point (quantities with subscript 1), we need first to estimate the magnitude of the bending moment vector M. Standard dimensional analysis yields

$$M \sim \rho\nu \frac{a_1^4 U_1}{R^2}\,. \tag{4}$$

Combining this estimate with eqs. (2) and (3) and noting that $\mathrm{d}/\mathrm{d}s \sim R^{-1}$ in the coil, we find

$$F_{\text{viscous}} \sim \rho\nu a_1^4 U_1 R^{-4}\,, \tag{5a}$$

$$F_{\text{gravitational}} \sim \rho g a_1^2\,, \tag{5b}$$

$$F_{\text{inertial}} \sim \rho a_1^2 U_1^2 R^{-1}\,. \tag{5c}$$

Note that each force is directly proportional to the quantities that describe their driving mechanism, i.e. $F_{\text{viscous}} \propto \nu$, $F_{\text{gravitational}} \propto g$ and $F_{\text{inertial}} \propto U_1^2$.

Depending on how the viscous forces are balanced, three coiling modes are possible. The simplest case occurs for small fall heights. In this regime (viscous regime), both gravity and inertia are negligible and the net viscous force on each fluid element is zero. The radius of the jet is nearly constant, $a_1 \approx a_0$, and the liquid behaves like toothpaste squeezed from a tube (see Fig. 2 a)). From dimensional analysis and the general relation $\Omega \sim U_1/R$, we find the scaling laws

$$R \sim H \equiv R_V\,, \tag{6a}$$

$$\Omega \sim a_1^{-2} Q H^{-1} \equiv \Omega_V\,. \tag{6b}$$

Increasing the fall height, we find the gravitational regime. In this regime, the jet's radius is no longer constant due to gravity-induced stretching (see Fig. 2 b)). The viscous forces acting on the fluid are balanced by gravity, such that we can derive the scaling laws

$$R \sim (\nu Q/g)^{1/4} \equiv R_G\,, \tag{7a}$$

$$\Omega \sim g^{1/4}\nu^{-1/4} a_1^{-2} Q^{3/4} \equiv \Omega_G\,. \tag{7b}$$

Further increasing the fall height triggers inertial effects (see Fig. 2 c)) due to the fact that the fluid velocity in the tail is much bigger than that at the injection point, $U_1/U_0 \gg 1$. In this case (inertial regime), viscous forces are balanced by inertia and the scaling laws are

$$R \sim \nu^{1/3} a_1^{4/3} Q^{-1/3} \equiv R_I\,, \tag{8a}$$

$$\Omega \sim \nu^{-1/3} a_1^{-10/3} Q^{4/3} \equiv \Omega_I\,. \tag{8b}$$

To complete the above scaling laws, we need to find a_1. The jet's radius in the coil is controlled by the gravity-induced stretching that occurs in the tail. A simple model to describe the jet's radius along the fluid column is obtained by taking the $\mathbf{d_3}$ component of the force balance equation (2) and assuming unidirectional stretching (along the jet axis). The differential equation describing the fluid velocity component U is, in this case,

$$3\nu U(U'/U)' + g - UU' = 0\,. \tag{9}$$

The three terms in this equation represent the viscous resistance to stretching, gravity and inertia, respectively. The boundary conditions for this simple model

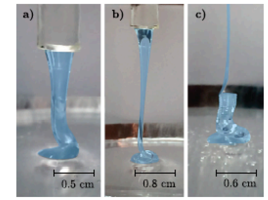


FIG. 2: Pictorial representation of the three coiling regimes: a) Viscous regime; b) Gravitational regime; c) Inertial regime. Note that picture c) was zoomed on the coil region to capture the small helical coiling structure.

[1] The analysis performed here follows closely [5]. Refer to the full text for further details.

ARTICLE

“LITERATURE REVIEW” ARTICLE

A Review on Brain Computer Interfaces

Hugo Pereira Hugon
Instituto Superior Técnico (IST), 2013
Prof. Filipe Rafael Joaquim

Brain Computer Interfaces (BCIs) research has been of growing importance within the aim of restoring movement and providing communication capabilities to people with paralysis. A review of the technology with its advantages and disadvantages is presented, as well as an overview of recent achievements, problems and future perspectives

1.Introduction

A Brain Computer Interface (BCI) is a device that allows the brain to communicate with a computer or another type of device to the external world. BCI creates a channel of communication that can work without muscular action, using only the brain electrical activity [3]. BCIs main goal is to provide a certain level of communication (word processing, neuroprosthetic control, web navigation, etc.), physical independence and quality of life to people with severe mobility problems, such as locked-in syndrome, cerebral palsy, muscular dystrophies, multiple sclerosis, brainstem stroke or spinal cord injuries. These diseases are a global problem, and affect more than two million around the world [5], what explains the fact that nowadays, more than 100 groups are studying this subject [3]. It constitutes a very broad multidisciplinar field, from neuroscience to rehabilitation technics, engineering or psychology. Studies have been made on animals and humans, and provided hopeful, yet still embrionary results, allowing, for example, paralyzed and severely disabled people to communicate through virtual interfaces.

A typical BCI system may require user training. It has a *sensor* that records neural data from brain activity, and a neural *decoder* wich translates that data and converts it into a command signal to an *actuator*, that perfoms the desired action [4]. The signal processing between the sensor and the actuator must be done online and reflect an intentional mental goal of the user (e.g. moving a robotic arm, or choosing a character from a virtual keyboard). A feedback of anykind must be provided (usually visual or auditive) to indicate the success or not of the process [2]. Feedback is a valuable source for the brain to adapt and optimize, in order to achieve each time improved results. Complex translation algorithms are needed to process specific and relevant signal features, turning them into control commands.

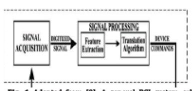


Fig. 1 Adapted from [9]. A general BCI system, where the signals that come from the brain are recorded, for example, by an EEG, and then go through an ADC into the signal processing, where the main features of the signal are extracted and treated by mathematical algorithms. The signal is now a device commad that will serve, for example, to move a cursor on a screen, or to close or open a prosthetic hand.

2.Types of BCIs

BCIs can be divided in *invasive* or *direct* BCIs, and *non invasive* or *indirect* BCIs [1]. Non invasive BCIs record signals from outside of the cortex, and are usually done by placing electrodes outside of the scalp. Those recordings are of collective

(thousands of) neurons activity. EEG (electroencephalography) based BCIs have been mostly used in non invasive methods. These tecniques are easier and safer to perform than invasive techniques, but cannot perform individual neuron measurements. They are more subjected to background noise, because of the skull, scalp, cerebral spinal fluid, and other cranian layers. Invasive BCIs are devices that, contrary to non invasive, can record many individual neuron's activity inside the cortex, providing signals with higher signal to noise ratio[5], and faster and multidimensional control [3]. Usually these systems are based on ECoG (electrocorticography) signals, and can be used to record on the same cortical areas that were injured or damaged. This reduces substantially the often BCI-patient learning needs, and can in principle be used to perform tasks regardless of other cognitive or mental activities [4](e.g. moving a prosthetic limb while performing visual activity). Although the improvements it carries, this method requires much more care in order to prevent and treat infections, possible rejections of the tissue, needs a cranian surgery, and has to take in account that, in general, the device will have to stay in the patient for a lifetime. Examples of invasive BCIs are the neurotrophic electrode[8][Fig.2a], or the Microelectrode arrays[7] [Fig.2b].

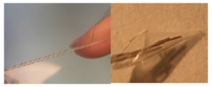


Fig.2a Taken from [8], a cone shaped glass device with two to four wires , that requires hours of expertise work to assembly, and achieves stability of signals and longevity letting neurites growing on it through the glass cone, turning into axons within three or four months. No tissue strain is yield with this process. Experiments have been made with this device and patients demonstrated control over a computer cursor[4].

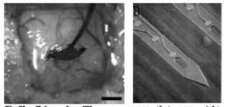


Fig.2b Taken from[7], a process that uses eight photolitography masks, allows customized neural targeting. A microelectrode constituted of 4 penetrating shanks, each of them with 4 recording sites, and a oval hole for tissue growth facilitation. The microelectrode is cantilevered to a microconector. High quality measurements were achieved with this device with tests made on rats.

Despite their instalation and surgical complexity, intracortical devices have been placed in more than 25000 persons [4].

3.Signal acquisition

There are many ways to receive the signals from neural activity. These processes can be invasive and non invasive, direct or indirect. The most common are, as said before, ECoG and EEG, wich are invasive and non invasive, methods, respectively, that measure electrical activity from the cortex. Other systems can be used [3], in a direct or indirect way: MEG (magnetoen-cephalography) directly measures magnetic fields produced by the currents flowing through neurons. MEG is non invasive, and more insensitive to distortion through the layers of scalp and skull, although, this technology is not very used because it is not practical and too expensive; NIRS (Near Infrared Sepctroscopy) and fMRI (Functional Magnetic Resonance Imaging) are non invasive technologies that provide indirect measurement of the neural activity, both by indicating metabolic changes related to that activity. fMRI detects changes in the cerebral blood flow and oxygenation levels, and NIRS uses infrared light to penetrate the skull, and to characterize fluctuations in cerebral metabolism of oxyhemoglobin and deoxyhemoglobin, by means of the

light intensity attenuation. Experiments have been done [4] that comprove the feasibility of a fMRI-based BCI, with still some practical limitations.

4. Type of Signals

The cerebral activity signal recorded by the acquisition system must be chosen in order to give the best translation of the user's mental intention. It is not trivial to choose a type of signal that corresponds to a certain visual stimulus, or a mental activity underlying a boolean or movement thought.

Different types of signals arise from different kinds of stimulus, or are inherent to the cerebral activity, and can be controlled by the user:

Sensorimotor Rythms are natural EEG rythms on the primary sensorimotor cortices. Studies show [9] the possibility of users to control them and use it to move a cursor on a computer; similar results (both learning and cursor control) were achieved with *Slow Cortical Potentials*. These are voltage shifts in EEG recordings that vary from 0.5s to 10s; *P300 Evoked Potentials* are positive peaks in EEG, and appear around 300ms after auditory or visual stimulations. *P300*-based BCIs do not require user training, since they are somatic responses to stimulus, but can lose efficacy while the user gets used to it. They have been applied on BCIs on a spelling 6x6 matrix of characters device, where the user would choose the desired letter within flashing rows and columns [9]; *VEP* signals are result of visual stimulation, such as intermitent flashes or random-dot maps. *VEP*-based signals also do not require training, and are the ones who offer more rapid information transfer. *VEP*-based BCI (see [2] for a more extensive insight) experiments have been made, showing high success rates within a virtual environment scenario with both healthy and disabled persons [Fig.3].

Fig.3 Taken from [2]. With a VEP-based BCI, an avatar could move within a virtual environment, depending on wich of the three visual stimulus (up, left and right of the avatar) the user would focus attention. Each stimulus was flashing at a different frequency, and depending on wich the user would glaze, a *turn left, turn right or walk one step* command would be made.

After the recording of the signal, the big task is to choose in an optimal way the relevant aspects of the signal.

Dimensional reduction methods or time/frequency methods such as matched filtering are used (see [3] for more extensive insight).

5. EEG based BCIs

An EEG based BCI is a good example to explain the most part of current BCI systems.

It has been demonstrated that, after variable amount of training, subjects can produce EEG patterns in order to control an external interface in an intended way through a BCI [6]. This training is not needed for BCIs that work with stimulus related signals. Within systems who rely or not on external stimulus, BCIs can be *synchronous* or *asynchronous*. In a synchronous BCI, events are analyzed in a predefined time. Synchronous can only take actions within a system time window, being warned when he shall interact, usually by means of a visual or auditory cue. Asynchronous BCIs give a more natural and intuitive experience in the sense that the subject chooses to interact when he wants to. Although, these are more complex in computing and treating data. The continue scan of brain signals produce a lot of events wich are not related to the ones BCI analyzes as user's intended action. Therefore, it needs

ARTICLE

plagiarism

/ˈpleɪdʒərɪz(ə)m/

noun

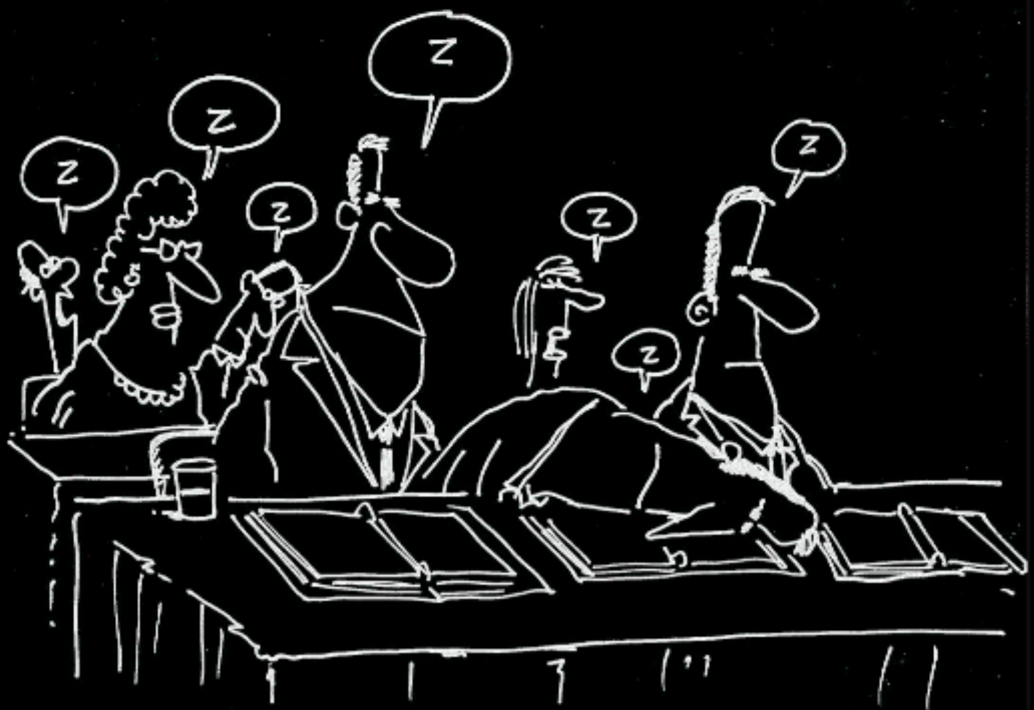
the practice of taking someone else's work or ideas and passing them off as one's own.
"there were accusations of plagiarism"
synonyms: copying, infringement of copyright, piracy, theft, stealing, poaching, appropriation;
informal cribbing
"there were accusations of plagiarism"

Translations, word origin, and more definitions

PRESENTATION

MOTIVATE, ENGAGE AND KEEP AN AUDIENCE

NOT AN EASY TASK!



PRESENTATION

THERE ARE NO RECIPES TO MAKE A GOOD PRESENTATION

BUT…

THERE IS A LIST OF THINGS THAT YOU SHOULDN'T DO.

AND THAT YOU FREQUENTLY DO

LIKE USING TINY FONTS IN YOUR SLIDES. CAN YOU READ IT BACK THERE?

FINAL REMARK ABOUT THE PROJECT

Literature revision project: Maximum project grade 17

(but no limit on the article grade)

Project with experimental/simulation/data acquisition:

NO LIMIT

IN SUMMARY

I WANT YOU TO BE RESPONSIBLE FOR THE FULL PROJECT

- CHOICE OF THE TOPIC
- RESEARCH
- COMMUNICATION

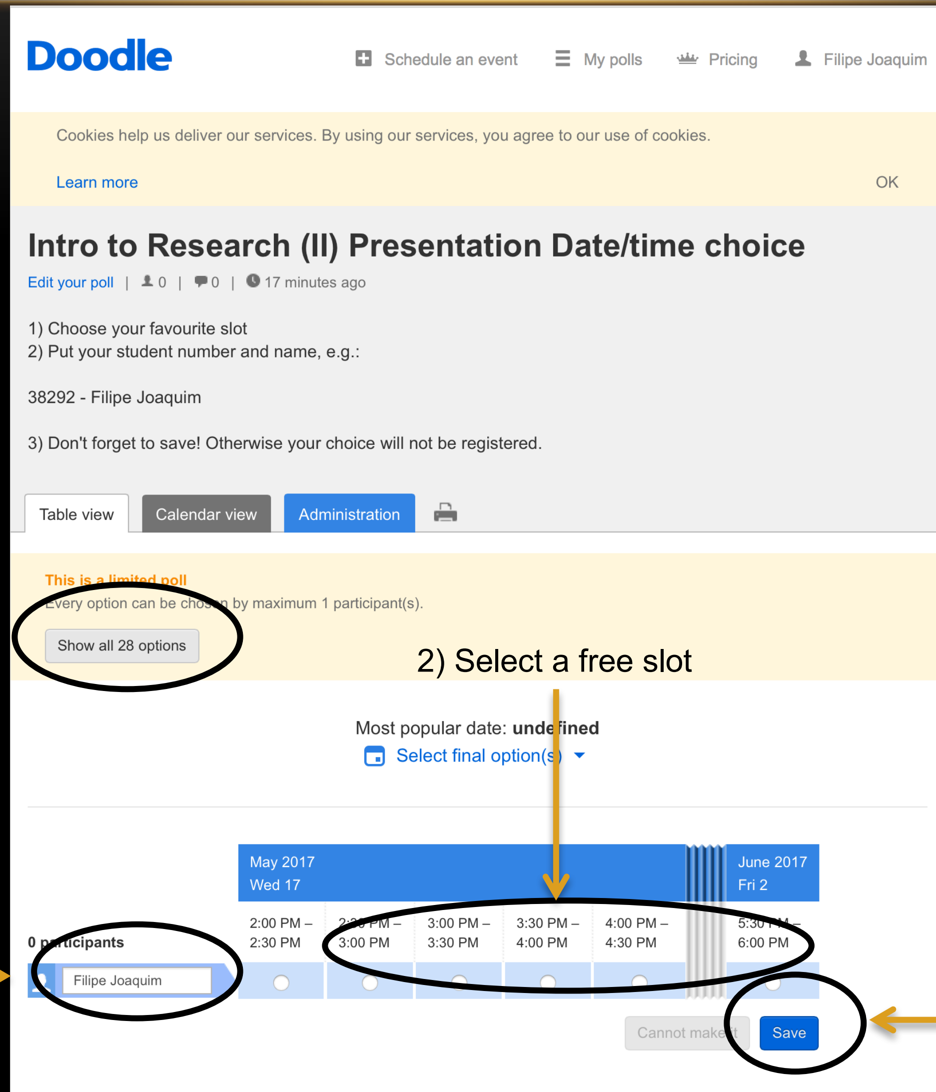
CALENDAR

Expand all options

1) Insert your number and name
Ex.: 38292 – Filipe Joaquim

2) Select a free slot

3) Don’t forget to save



CALENDAR

PRESENTATION DATES: 17,24,31 May and 2 June

THE LINK WILL BE AVAILABLE **FRIDAY 24 FEV AT 10PM** ON THE WEBPAGE AS AN ANNOUNCEMENT

YOU SHOULD CHOOSE YOUR TOPIC UNTIL MARCH 8

SEND A PRELIMINARY TITLE TO filipe.joaquim@tecnico.ulisboa.pt

It is important that you let me know as soon as possible about the topic since there can be no overlap with previously presented projects.

COLLOQUIA

COLLOQUIA ARE FOR YOU!

Even if the topic is not related with your thesis topic/interests…

TRY TO SEE BEYOND THAT!

INTERDISCIPLINARITY/SINERGIES

DON´T FORGET: There are more and less brilliant speakers, but they all spent time preparing the colloquium. So, speakers deserve respect. No cell phoning, no laptops, etc…