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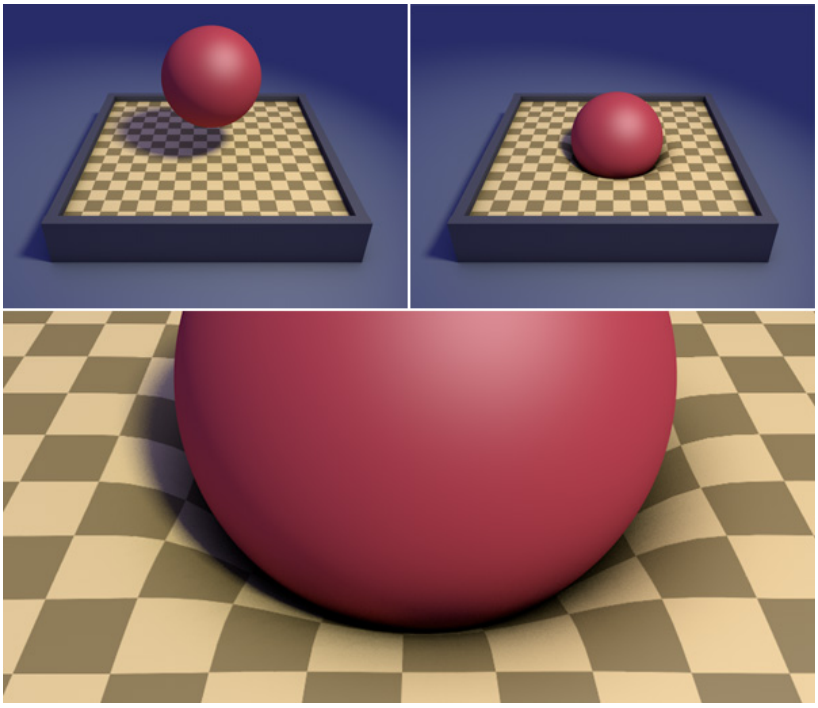
# Spherical indentation analysis

User guide



*http://nycppnews.com/reviews/joe-herman-reviews-cinema-4d-version-13/*

Informatics project

-

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INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

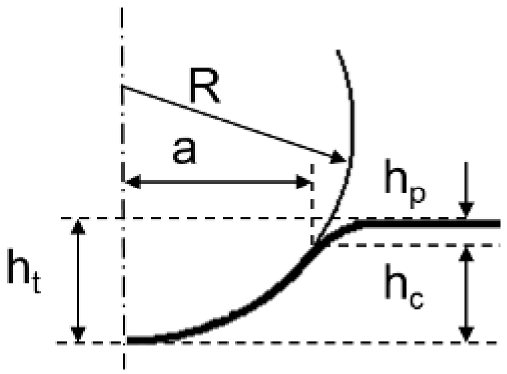
# <u>Table of contents</u>


Table of contents

- I. Scientific theory of nanoindentation
- II. How to use this program
  - First interface
  - Second interface
  - Third interface
  - Fourth interface
  - Fifth interface
- III. Contacts

## I. Scientific theory of nanoindentation

When we measure some characteristics of materials like stiffness, if the applied load on the indenter is too high, the indenter can be subject to strain and degrade the measures. A solution is to push the indenter very gently. this is called nanoindentation. The load is in the order of a few tens of micronewtons for a driving in of a few micrometers. Nanoindentation assays allow access to useful variables. This program focuses on the determination of Young's modulus and the stiffness of the material.




Triangular or polyhedral tips like Berkovich's or Vickers' are among the most commonly used. The assays we will study will be made with a spherical indentation tip. Indeed, these kind of tips drive in less deeply in the sample. Their performance is consequently elastic for low loads. As there are no edges, the measuring process is less likely to generate cracks in the material.

To be able to calculate the stiffness H and Young's modulus E, we first need to determine the contact area.

$$h_c = h_{\max} - \varepsilon \frac{P_{\max}}{S}$$

where P is the load applied on the indenter, $h_{max}$ the highest driving in and ε a parameter taking the shape of the tip into account. For a spherical tip, ε equals 0.75. Once we have the value of the linear driving in $h_c$, we can get the contact area $A_c$ :

$$a = (2Rh_c - h^2{}_c)^{\frac{1}{2}} \text{ puis } A_c = a^2\pi$$

From this, we can easily get to the values of the Young modulus and stiffness. The stiffness we measure is the one of the whole system, which means both the sample and the machine. Let $\frac{1}{S_{matériau}} + \frac{1}{S_{machine}} = \frac{1}{S_{total}}$. Since we don't know the stiffness of the machine $S_{machine}$, we need to calibrate the assay with materials that have a known Young's modulus. we measure $S_{total}$, and we know $S_{matériau}$ (stiffness of the material). Therefore, we can deduce $S_{machine}$ and get all the values.

## II. How to use this program

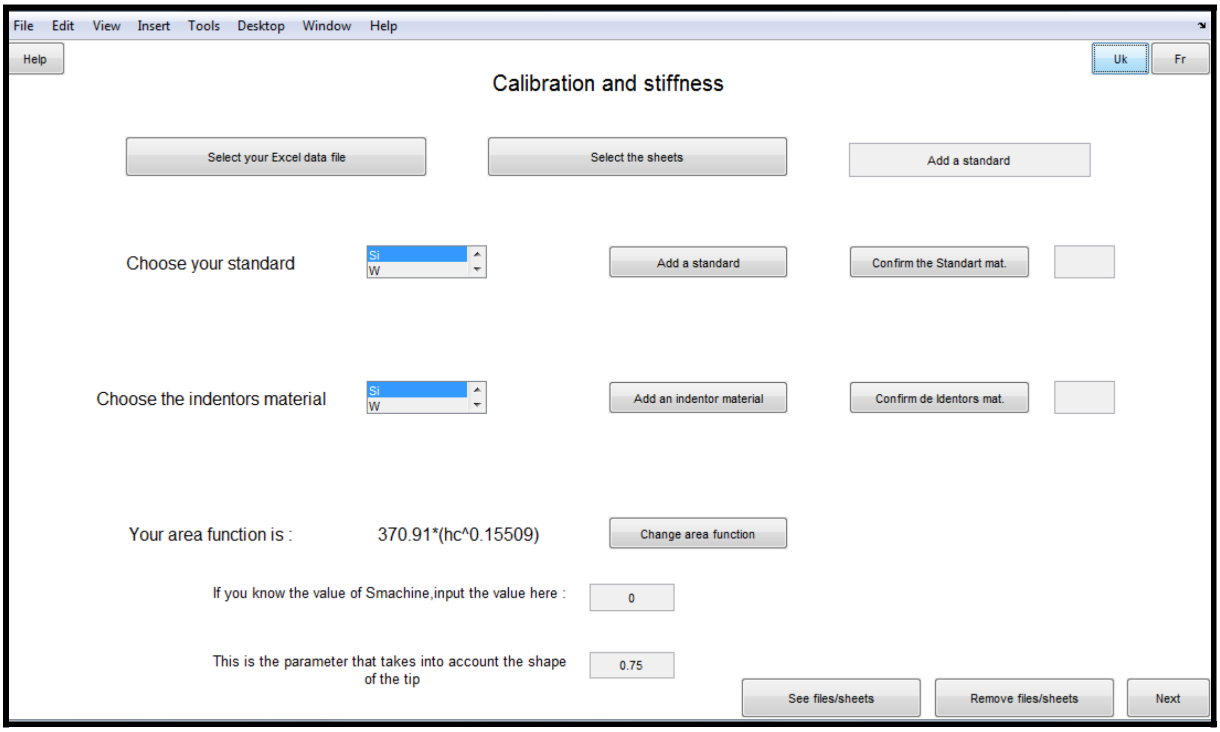
First :

- Please check if Matlab is installed on your computer.
- Open the folder then double-click on the **"main"** file to open the graphic interface/

Language buttons allow you to choose the language you will use for this program. The **"help"** button will give you some instructions.

This program includes five interfaces.

### First interface




It allows you to choose your sample and your calibration material.

Please follow these steps :

1. **"Select your excel data file"** allow you to choose files for **"Calibration"** (Silica, for example) and **"sample"** (Biolox, for instance).

2. **"Select the sheets"** allows you to choose the right number of Excel sheets. You will also have to type in their names.

3. Now select a standard for calibration **and** a sample material.
    a. You can use **"Add a standard"** to add a new material that isn't in the default data list. You will have to give its Young's modulus, its Poisson's ratio and its name.
    b. The **"Add an indenter material"** button allows you to add a material that isn't on the default list.

    To make sure your choices are saved, click two times on the material name in the scroll bar. You can also use the validation buttons.

4. **"Change the area function"** allows you to use any rating you want.

5. **"See files/sheets"** allows you to check the files and the sheets you chose.

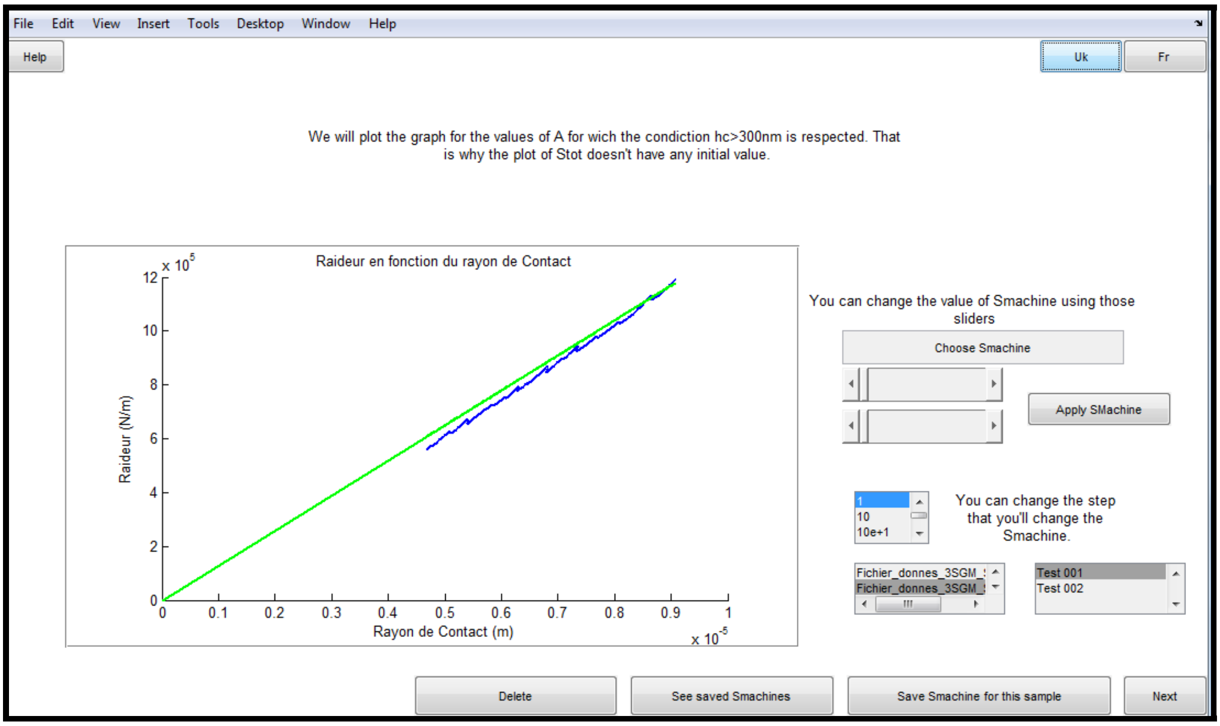
6. **"Remove files/sheets"** allows you to delete the files you don't want.

7. **"Next"** to move on to the next interface.

8. **"If you know the value of $S_{machine}$, input the value here"** saves you some time if you already know a value of the stiffness of the machine.

Selected files and elements are displayed on the right.

## Second interface




This interface is made to find $S_{machine}$. The user will have to line up the experimental curve with a theorical linear function.

After giving a value of $S_{machine}$ (around 35.000.000 in our case), we can refine with the scroll bars. You can then choose which test you will check in which sheet with the menus. Don't forget to click on **"Apply $S_{machine}$"**!

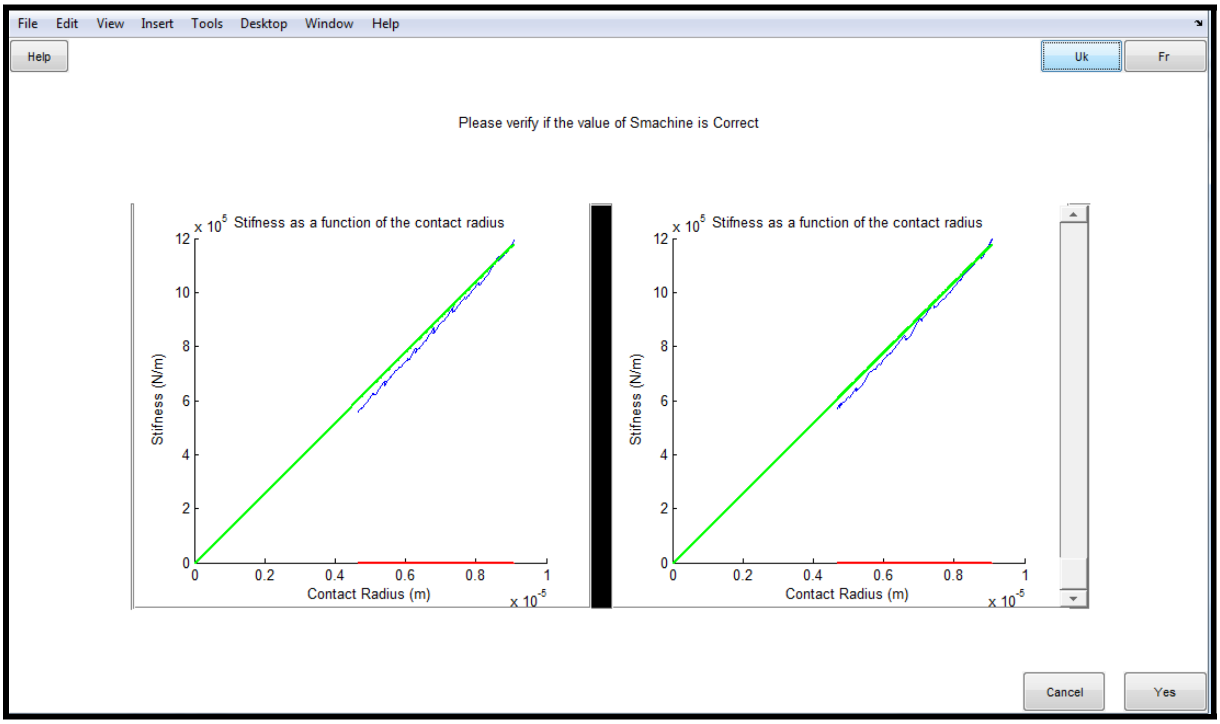
**"See saved $S_{machine}$"** allows you to check your values.

**"Delete"** allows you to remove some of the values if you find them to be incorrect/

**"Save $S_{machine}$ for the sample"** allows you to save the graph under the format that you want.

Click on **"Next"** to move on to the next page.

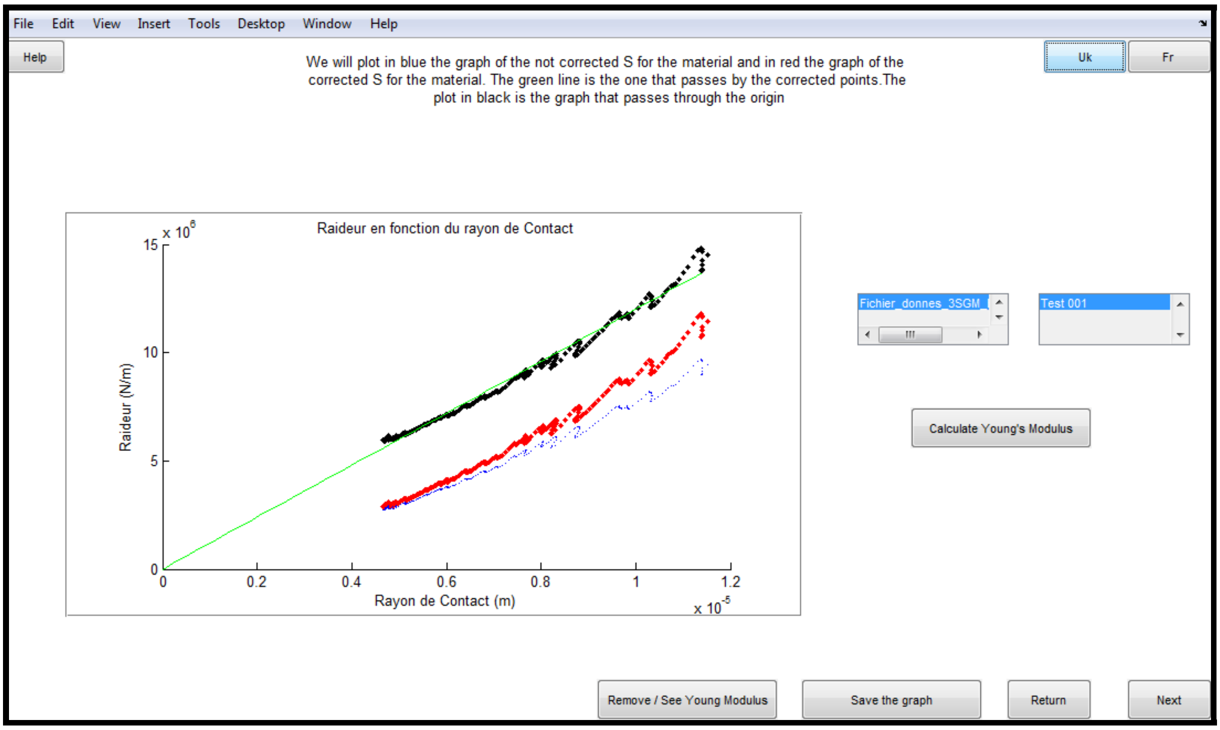
## Third interface




Here you can check if the value of $S_{machine}$ you chose is working. the interface displays the graphs of $S_{machine}$ in function of $a$ for every sample. Use the scroll bar to see all of them.

If the result suits you, click on "Yes". Otherwise, click on "Cancel" and you will be directed to the previous interface.

## Fourth interface




On this page is displayed a recap of the curves.

- The blue curve is the uncorrected stiffness (without $S_{machine}$)
- The red curve is the corrected stiffness.
- The green line is a linear approximation of the corrected stiffness. The black curve is the same as the red one, but with an offset so the linear approximation has a Y-intercept of 0.

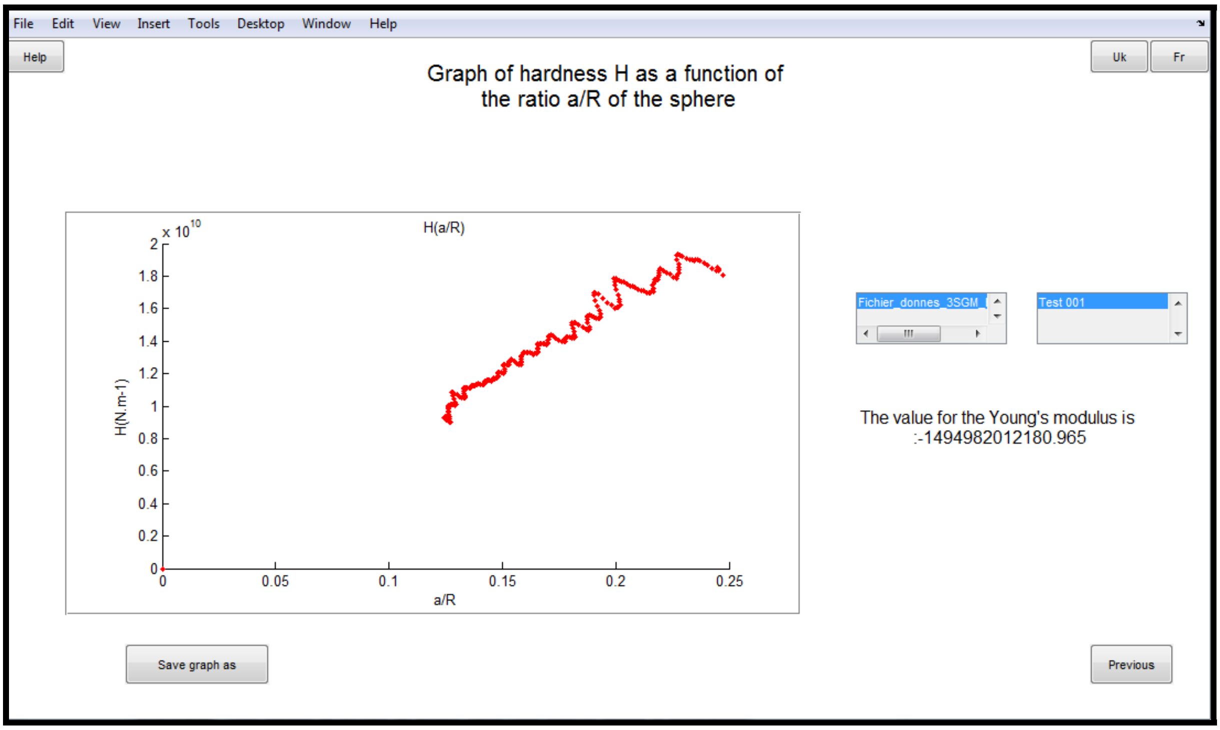
Clicking on **"Calculate Young's modulus"** will display the Young modulus of our sample.

**"Remove/see Young's modulus"** allows you to delete a value by double-clicking on it.

**"Save the graph"** allows you to save the graph under the format that suits you.

Click on **"Next"** to move on to the last interface.

Fifth interface




This last page displays $H = f(\frac{a}{R})$.

You can choose the sheet and the test you want.

**"Save graph as"** allows you to save an image of the graph under various formats.

**"Previous"** allows you to go back.

When you are done, after saving the curve, you can close the program.

## **III. Contacts**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