Transposing multimedia into a virtual course

by
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Engineering, graphical representations, Java, multimedia.

INTRODUCTION

The present paper describes the challenges posed by transposing a successful conventional course [1] into an – hopefully – equally successful web-based course, with the name *i-Structures*. This work is under way as part of the Swiss Virtual Campus project. The *i-Structures* project team is composed of members from the Swiss Federal Institute of Technology in Lausanne, the Swiss Italian University in Mendrisio and Lugano, the Swiss Federal Institute of Technology in Zürich and the University of Applied Sciences in Manno.

In addition to the use of text and illustrations, technical courses, in the present case engineering courses, often make use of some multimedia components, in the form of in-class demonstrations, videos and models. The course of Structures at the Accademia Architectural school of Mendrisio relies heavily on in-class model testing and experimentation to give the students a feeling for the way structures behave. Since its inception in 1996, this course has been a big success, even to the point of making this very technical course a favorite amongst architecture students.

The idea behind the project proposed to the Swiss Virtual Campus in its second call for projects was to transpose this course into a web-based course that would offer both the teacher and the students more possibility for interaction with the phenomena and more freedom to consider complex problems. At the same time, the idea was to also extend this course to civil engineering students, who, in the process of being trained to use analytical method, often lose sight of the way structures work, and are often less creative in their approach to structural problems.

USE OF MULTIMEDIA IN A CONVENTIONAL COURSE

As it is currently taught in Mendrisio, the Structures course makes a wide use of various types of models. Some are very simple, as a string or chain attached on a blackboard, as show in figures 1 and 2. The use of a chalk line marking former positions allows to precisely follow the effect of loads on the structure.

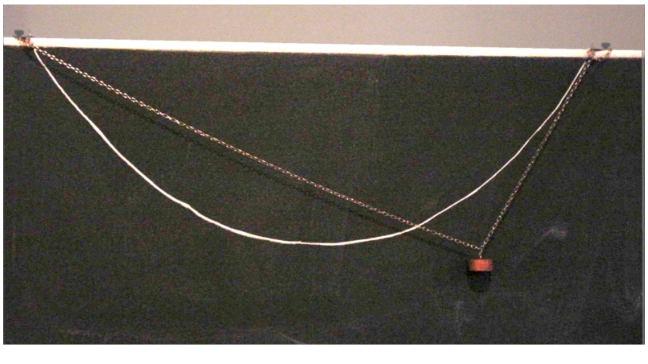


Figure 1: String with one load, compared to the position of the string under it self weight (catenary curve)

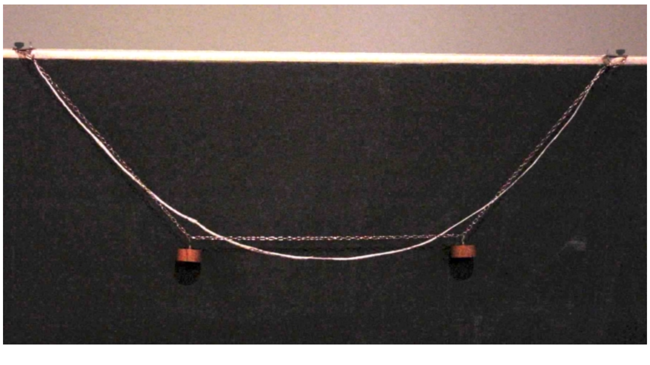


Figure 2: String with two symmetrical loads

Figure 3 and 4 show more complex models used to illustrate the behavior of trusses and guying cables. Students get a direct feeling for the stiffness and the mode of behavior of the structures.

The course is also enriched with showings of video footages, and many photographs of existing structures. Graphical calculations (see below) are routinely performed on the overhead projector, with the instructor drawing on the overhead sheets while the students take notes.

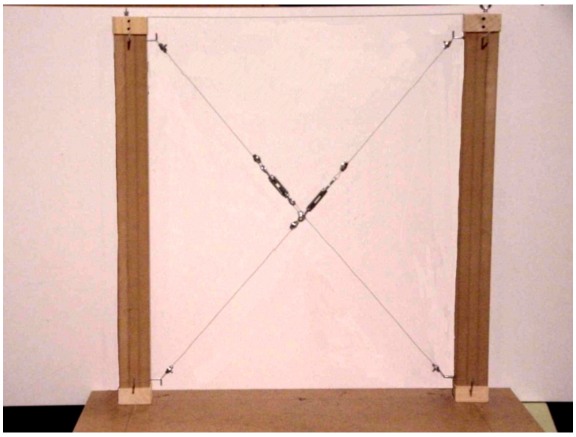


Figure 3: Truss with stabilizing strings

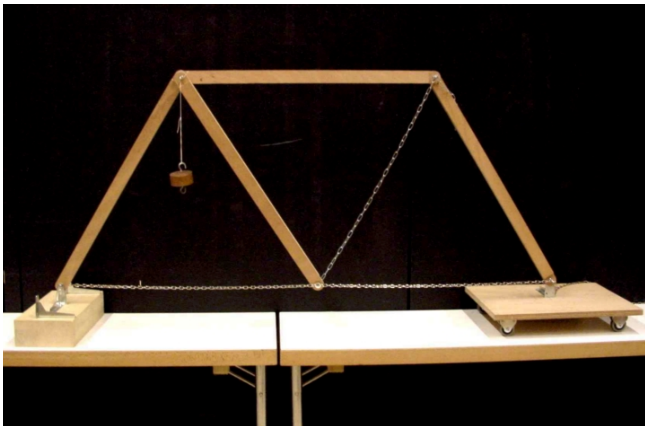


Figure 4: Truss under an eccentric load. Notice the element in tension (chains) and in compression (bars)

GRAPHICAL STATICS

The *conventional* Structures course relies a lot on graphical statics, an ancient way of calculating structures, that dates back to the XIXth Century. Since the introduction of computers, this method has progressively disappeared from engineering curricula, to make place to more computer-friendly analytical methods. Graphical statics, however, have great pedagogical value, in that it allows a visualization of the path of forces in structures, and an intuitive understanding of the way structures work. This method is very suitable for architectural students, who are typically very oriented towards graphical methods and representation, and have on the other side little interest for purely analytical methods.

The problem with graphical methods of analysis is that they are time-consuming, and that the calculation process is quite repetitive. This has brought some problems in the course as it is given in Mendrisio. Because of the rather long time that is required for the solution of each example, less time can be devoted to the discussion and generalization of the methodology. Also, any change in the parameters of the calculation requires an entirely new process, which makes parametric studies impractical. Of course, the use of computer-base graphical statics solves many of these limitations.

USE OF MULTIMEDIA IN A WEB-BASED COURSE

Multimedia is certainly one of the most appealing factors in the process of developing a web-based course, as compared to preparing a conventional book. On the web, color photographs and drawings are available for free, and the possibility to add some animations to illustrate processes is very exciting. Table 1 lists possible uses of multimedia on the Web.

For the purpose of developing a Web-based counterpart to the existing course, it became rapidly evident to the project team that simple animations or simulations would not be sufficient. Figure 5 shows an attempt at applying the well known Cinderella environment [2] to graphical statics. The complexity of the construction, evidenced by figure 6, shows that it would be impractical to require students to use this tool to model their structures. Therefore, it was decided to develop a series of high-level modeling Java applets to enable both the teacher and students to model just about any structure that they may encounter.

Table 1: Possible uses of multimedia in web-based courses (in order of increasing interactivity)

Purpose	Technical means
Illustration	Color photographs and drawings VRML and other 3D representations
Animation	Flash and other animation platforms Video
Simulation	Java applets, with limited range of parameters
Modeling	Java applets with essentially no limitations

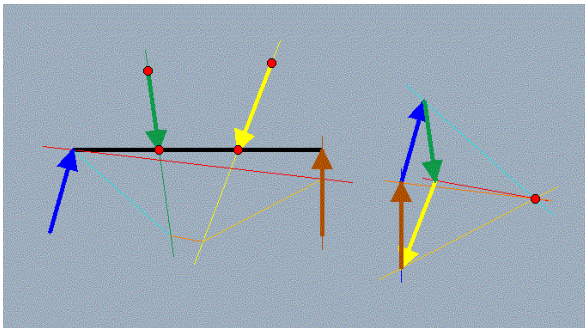


Figure 5: Graphical solution for a beam with two applied forces (Cinderella)

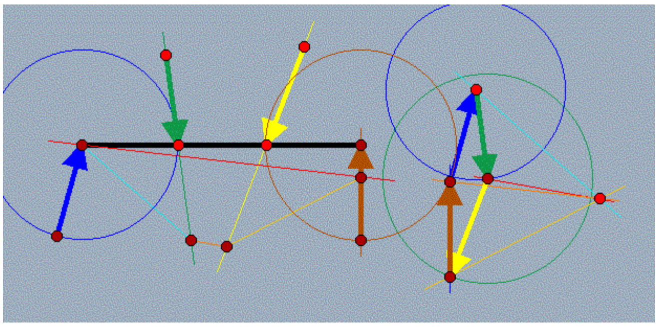
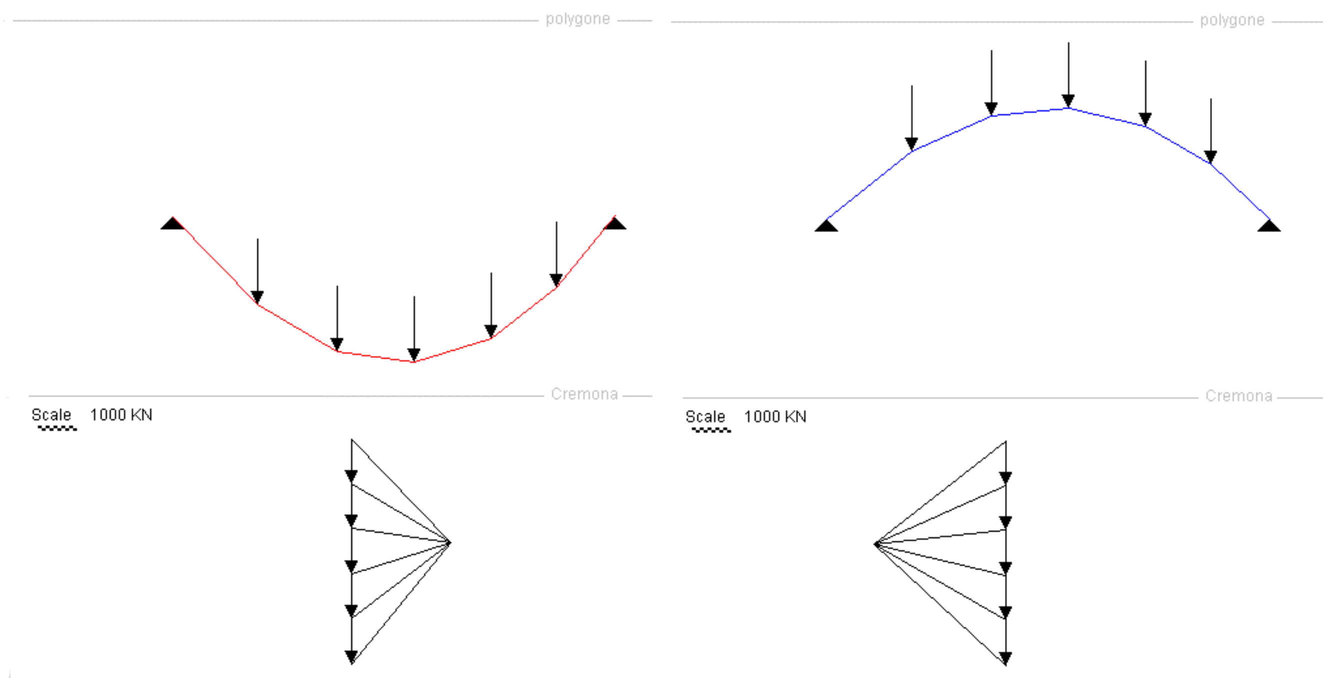


Figure 6: Same as Fig. 5, but with all construction lines shown

EXAMPLES AND EXERCISES IN I-STRUCTURES



a) Solution with only member in tension *b) solution with only members in compression*

Figure 7: Example of an applet showing various solutions for a given configuration of supports (black triangles) and loads (arrows). The upper part of the figure shows the configuration while the lower part shows the graphical resolution of the problem.

The *i-Structures* course is structured around a series of examples (in the classroom or web-based) and exercises. All use basically the same set of high-level graphical applets. These applets give the teacher the freedom to rapidly solve the problems during the lesson, as for example illustrated in figure 7, which shows a screen shot of a preliminary version of one of the applets. The location and amplitude of the forces can be chosen, and then the resulting forces are automatically calculated. The figure shows two possible configurations for a given configuration : one in compression (blue) and the other in tension (red). The geometry can bee interactively changed to study the effect of changes in the geometry or the loads on the results. A critical interpretation of the results can then be performed by the student, using parametric studies, what-if analyses to compare radically different solutions.

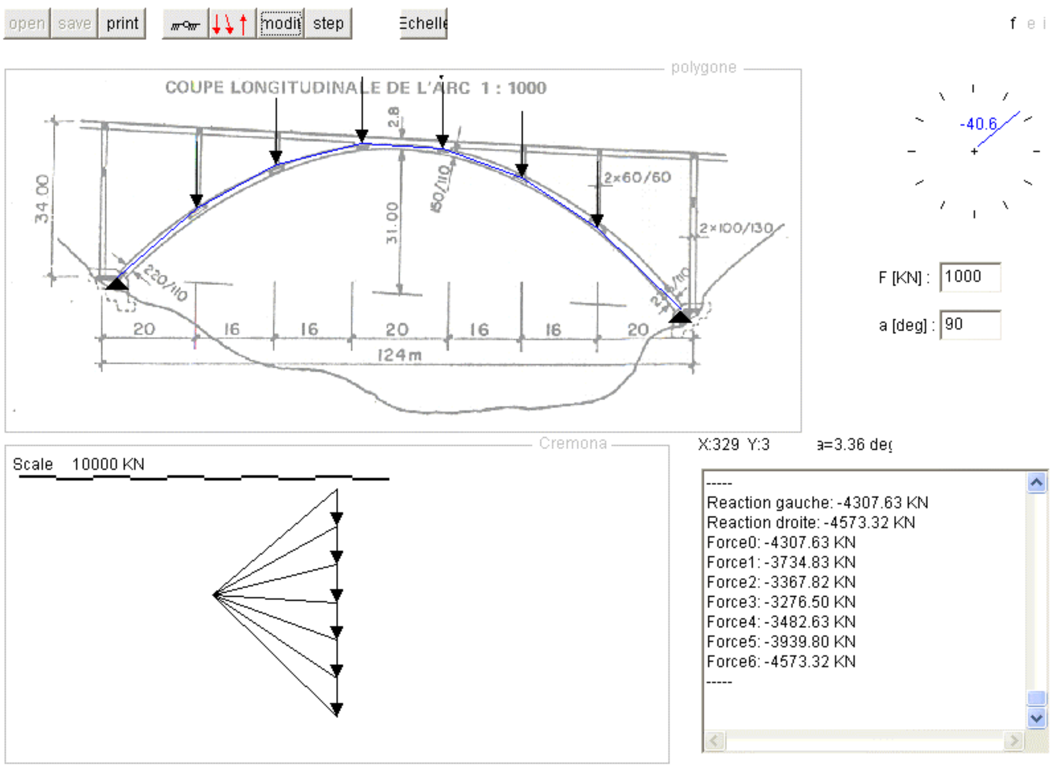


Figure 8: Applet showing the flow of forces superimposed on a drawing of an existing bridge

As shown in figure 8, the same process can be used in superimposing the calculated flow of forces over a drawing (or photograph) of an existing structure, with the aim of better understanding the way the structure carry its load. Students can use this tool to explore a variety of cases and gain a deeper understanding of the way structures work. More time can be devoted to learn from the observed behavior than previously. Students can not only access an identical copy of the exercises the teacher demonstrated in class, they can also apply it to their homework and, as is anticipated, use it to solve different structures, as they encounter them in other courses. The use of a Finite Element – based solution in addition to graphical statics will add very interesting possibilities, as the calculation of deflections, which are currently not treated in the course.

CONCLUSIONS

It is clearly too early to draw conclusions from the project. Some interesting questions have been raised, however, on the limits placed by current approaches of teaching with new media. These questions deal with the use of highly interactive multimedia, the evaluation of students based on their activity with these tools, and the necessary formation of tutors for such courses. These questions will be addressed further and will be presented in subsequent publications.

REFERENCES

[1] **MUTTONI A.**, *Strutture - un'introduzione al funzionamento delle strutture portanti in architettura*, Accademia di architettura, 167 p., Lugano, Switzerland, **1998**.

[2] **RICHTER-GEBERT J., KORTENKAMP U. H.**, *The Interactive Geometry Software Cinderella*, Springer-Verlag, 143 p., Berlin, Germany, **1999**.