

A Multimedia-based Approach to Teaching Engineering Drawing

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ABSTRACT

CIVL 114 is an introductory engineering drawing course taken by all first-year civil engineering students at HKUST. It covers not only CAD and manual drawing skills, but also how to interpret specialized construction drawings. In drawing classes of this nature, students may find it difficult to understand the construction drawing examples which are traditionally presented in 2-D drawings, due to a lack of site experience and proper interpretation and visualization skills. Moreover, when teaching CAD software, although live demonstrations are given in computer barns with ample lecture notes, some slow students missing just a step or two may then fail to catch up ever again in the subsequent discussions. To address such problems, we propose the use of an array of multimedia tools to allow students to better visualize construction drawing examples in 3-D, and to revise the traditional 'notes and live demonstration' approach to software teaching by an alternative strategy which utilizes screen-capture movies with voice and on-screen tips to explain the software operations.

Keywords

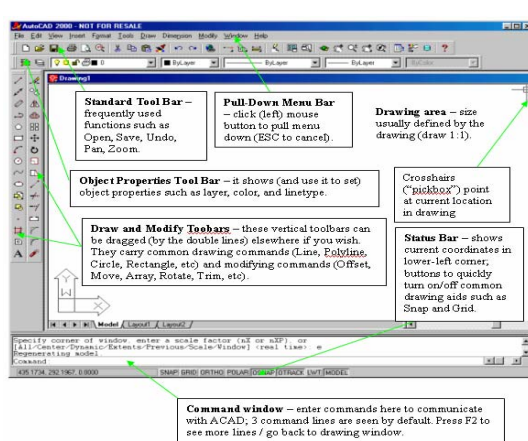
Computer graphics, animation, multimedia, screen-capture software, civil engineering

INTRODUCTION

We have been involved with the teaching and course development of CIVL 114 (Civil Engineering Drawing) for the past several years. This course covers manual as well as CAD drafting methods, with more emphasis on CAD as it is the current industrial standard. Moreover, the ability to understand complicated construction drawings is also an important skill to be acquired from this class, and this ability will be important to students in future classes and in their professional careers. From our observations in the past, students' typical difficulties in this class are found in two basic categories: (1) learning the CAD software, and (2) interpreting the construction drawings used in the class.

Student Difficulties when Learning CAD

When teaching CAD software, although live software demonstrations are given (in ITSC computer barns) slowly and patiently with detailed notes, such as those shown in Figure 1, some students may still miss a step or two, and subsequently fail to follow all the rest. This is a common problem when teaching a software. Such students may then request the whole sequence to be repeated for them, at the cost of slowing down the lecture pace to other fellow students. Moreover, seeing such demonstrations would become impossible when a student cannot come to class due to illness or other public emergencies such as a typhoon or a SARS outbreak. Furthermore, after the class, students still having questions about the software and/or interpretation of drawings may find it difficult to find answers themselves from the course material due to its static nature, while drawing is a dynamic process. Using the built-in CAD tutorial to find answers to their questions can be rather inefficient, akin to learning English by reading a dictionary. Although certain screen-capture CAD tutorial packages are available on the market, they are often of a general and mechanical nature and do not address the specific concerns and techniques required by our civil construction drawings, and drawing examples in commercial CAD tutorials are often mechanical drawings that are not very useful to civil engineering.



The following AutoCAD commands can be used to determine the coordinates of C:

1. Use POINT command (or Draw - Point - Multiple Points) to draw points A and B at their given coordinates. Exit POINT command, and Z(oom) - E(xtent) to see the 2 points drawn. If the default point style is too small to see, you can use Format - Point Style - (choose "X" type) to fix it.
2. Right-click "OSNAP" tab at screen's bottom, click Settings, and turn on the "Node" (NOD) and "Intersection" (INT) object snap option. The NOD option allows one to snap to a point.
3. Draw a LINE from points A to B using object snap.
4. Use ROTate (or Modify - Rotate) to rotate AB by $49^{\circ}27'18''$ into the direction of AC. Pick line AB when prompted to *select objects*, press enter, use A as *base point*, and give a *rotation angle* of $-49^{\circ}27'18''$. Note that AutoCAD takes counterclockwise angles as positive by default, and accepts the D/° format when specifying angles.
5. Redraw the line AB, then rotate it by $37^{\circ}14'36''$ about base point B. Draw the line AB again.
6. Use ID to find out the coordinates of the INTERsection point of the two lines on the screen.
7. From pull-down menu, Dimension - Style - Modify - (click Primary Units Tab) - change Angular Dimensions to D/M/S format with 0.1" accuracy - OK - Close.
8. Dimension - Angular, pick two lines to have AutoCAD calculate and label the angles between them. If the text is too small, set DIMSCALE to a new value (e.g. 1.5), and Dimension - Update - select dimension(s) to update. This will double-check the correctness of the angles input.

Figure 1. Typical CAD teaching material with graphics and text

Student Difficulties with the Interpretation of Engineering Drawings

When it comes to the interpretation of drawings, as students are not experienced engineers they often find it difficult to understand the real-life construction drawing examples given in class, such as that those shown in Figure 2. In order to fully understand the configuration of the rebars in such drawings, one must carefully examine these bars in multiple views together in the light of a thorough understanding of specialized nomenclature used in the construction industry. In Figure 2, there are rebars at the top and bottom of the structure, running in both the longitudinal and transverse directions, while some may seem to overlap others in certain views. First-year students may find it difficult to develop the skills to interpret such drawings in the short period of time available in a fourteen-week drawing class that must cover both CAD and manual drafting skills.

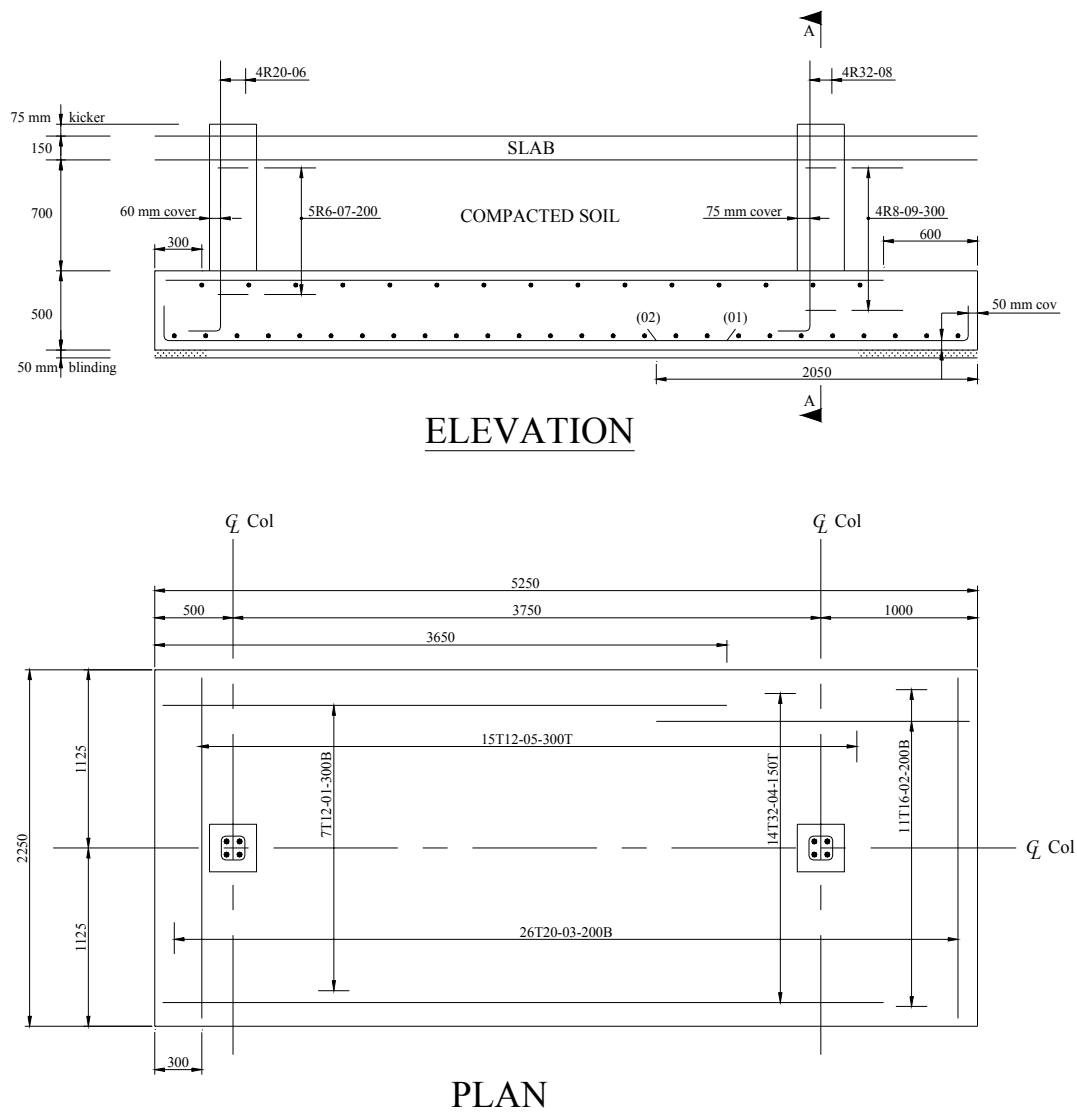


Figure 2. A typical construction drawing

USING MULTIMEDIA TO TEACH AND LEARN DRAWINGS

Teaching CAD with Screen-capture Software

It is evident that, when teaching computer software, using printed material and live demonstrations only may not result in the most efficient pedagogy. A better teaching approach would include screen-capture movies with voice and on-screen tips to explain the software operations. Such movies can be prepared using screen-capture software allowing the user to record the events that take place on any particular window on the user's computer screen, while call-outs with additional comments can be added after the recording to provide additional explanation of what is being done or what to do on the screen. Voice can be added during or after the recording, and the movie can be produced in AVI file format, which can be played on most computers. A screenshot example of such movies is shown in Figure 3.

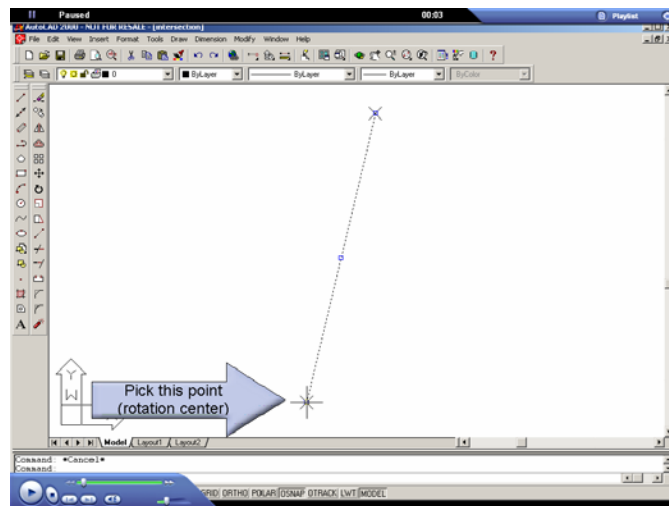


Figure 3. A screenshot of video instructions on CAD

There are numerous advantages that screen-capture movies can offer. Firstly, students can view these movies at their own pace, and repeat any part of the movies as frequently as they need. Hence, fast learners will not be slowed down by less efficient ones in the class. Moreover, even after the class, students can continue to use the movies to reinforce their learning. Such movies are also particularly useful should there ever be any personal issues or unexpected events preventing class attendance.

In response to the aforementioned software technology, the course content of CIVL 114 is being re-examined and re-written to combine the use of conventional lecture notes, CAD drawing examples and corresponding screen-capture files when teaching CAD. This new mode of delivery should result in reduced learning anxiety as the movie files will act like an instructor who will patiently repeat any step in the software operation as many times as the student desires.

Enhancing Understanding of Drawings with 3-D Animation

Although screen-capture movies can help students when learning software operation, the interpretation of drawings is a different matter. Construction drawings are often presented in 2-D as floor plans, sections and elevations, such as those shown in Figure 1, and many others in Madsen and Shumaker (1994) and Liebing (1999), etc. The problem with using mainly 2-D drawings is that students may experience difficulties connecting the various views mentally. To overcome this problem, 3-D animation can be used to supplement such 2-D material when teaching construction drawings. With reference to the structural drawing in Figure 1, there are mainly five sets of rebars (marked 01 to 05 in the figure), with sets 01 to 03 at the bottom, while sets 04 and 05 are located above them. To help students understand the location and orientation of each set of rebars, a 3-D model of this structure can be prepared with animation software. The particular set of rebars (01, say) the instructor wishes to explain will be made the prominent features by making all other rebars nearly transparent, while 01 will be shown to grow from one end to another during the animation. At the same time, the camera will be revolving around the structure to ensure the students see all the bars from different important perspectives, since it may be impossible to see certain sets of rebars at the same time in

single view (e.g., sets 01 and 02 would overlap in the elevation view). Similar to the screen-capture movies, the animations will also be prepared as AVI files which can be viewed by the students on VCD players or computers.

SUMMARY

The technologies introduced in this article allow engineering drawing instructors new pedagogical opportunities that can significantly enhance teaching and learning efficiency in drafting courses that involve CAD and the interpretation of structural drawings.

The use of 3-D animation is an effective means of presenting complicated construction drawings to students who are new to the subject. With such animations, students no longer have to rely on their imagination alone to assemble a complete picture of the engineering structures being discussed.

Using screen-capture movies provides an effective alternative not only for teaching CAD, but also for teaching other courses that involve software use, such as numerical analysis (which may require MatLab), engineering mechanics (which may require specialized analysis software), and business statistics (which may require SPSS or Excel). Incorporating screen capture movies as part of the course material can help students unfamiliar with the software. Since such movies facilitate self learning, they can also help instructors who do not wish to spend too much time prior to lectures discussing software operation, which may be a peripheral issue rather than the core subject matter of the course.

ACKNOWLEDGEMENTS

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