Using RADIANCE for teaching lighting simulations on a European Masters course

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26th August 2002

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Abstract

The Low Energy Architecture Research Unit, LEARN, has been running a MSc course on 'Architecture, Energy and Sustainability'. This is now accompanied by a European Masters in the 'Integration of Renewable Energies into Buildings'. One of the modules is on Building Simulations. It is split into Thermal and Lighting Simulations. For the lighting side, the RADIANCE simulation package is used. This talk will be about the setup of the resources used for the course. The layout of the course taken will be presented together with the course notes. The feedback from the students will be discussed and future improvements laid out.

Introduction

The MSc in Architecture, Energy and Sustainability at the University of North London (now London Metropolitan University) was launched 4 years ago. It was later expanded into the European Master in the Integration of Renewable Energies into Buildings. The courses are tailored for professionals working in the built environment who want to acquire specialist skills and knowledge in low energy design, an increasingly important international field. They give a practical and theoretical grounding to architects and building professionals. Skills are developed in a range of different methodologies for evaluating environmental conditions and predicting the effects of design solutions. These include data collection and interpretation methods and computer-based simulations of buildings, set within a framework of low energy design principles, and against a background of often conflicting theories of sustainability.

One of the modules taught on both courses is Building Simulations. It is divided into thermal and lighting simulations. For the lighting side, the RADIANCE software package was chosen due to its free availability, its versatility and accuracy. Although a Windows version existed at the time, it was found to be less functional than the version running under the UNIX operating system which had been used within the research unit for many years.

Setup

In the first year of running the Masters course, three disused Intel 486 machines were set up to run RedHat Linux and RADIANCE. However students not familiar with Linux experienced difficulties with transferring files and were generally unwilling to accept work stations which did not run a Microsoft operating system. To add to the list of drawbacks of this setup is the fact that monitors, graphics cards, and input devices were rather old and did not satisfy modern requirements to human interface devices.

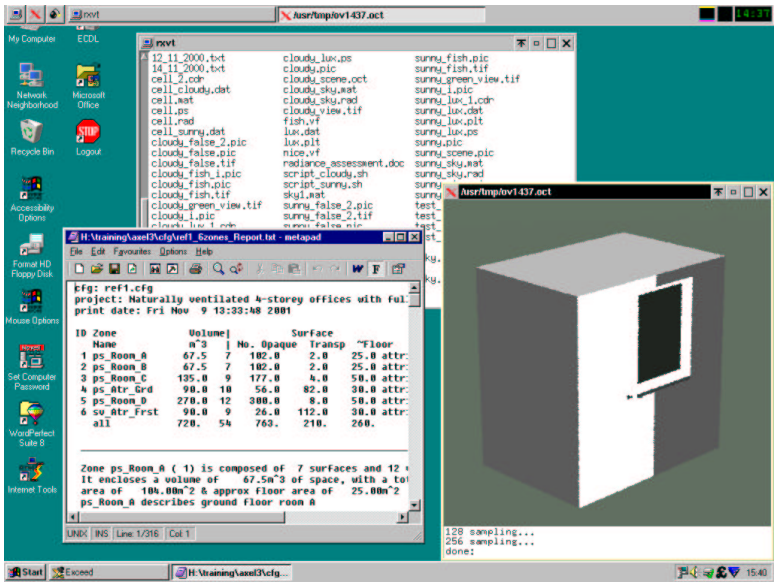

Figure 1: X session through Exceed under Windows NT. Note the additional Linux task bar at the top of the screen. The text editor is MetaPad running under NT, the shell window and rview are running on the Linux server.

The school has an extensive student IT lab with many NT and Macintosh work stations. To overcome the problems encountered in the first year, it was decided to follow a completely different strategy in the second year. The build on six of the NT machines was modified to allow their use as X terminals. This could be done at zero cost due to the fact that the university holds a site license for Hummingbird Exceed. This made the use of the Windows boxes as X terminals to Linux servers possible.

On the server side, two dual processor Pentium machines (300 and 450MHz) with 256MB of RAM were brought up under RedHat Linux. The only additional software installed on them was RADIANCE and ESP-r which is used for the thermal simulations. While the number-crunching is done on the servers, the user input and display takes place at the NT terminals utilising their 17" monitors and fast graphics cards.

The student machines are configured in such a way that no user data is held on the box but on a Novel network drive instead which is auto-mounted at login. This setup made it possible to remount the student home area on the Linux server. This way, the project files could be accessed both, in the X session and locally under Windows. The advantage is that the students can work in their familiar desktop environment, allowing them to transfer files through local floppy and Zip drives and to edit configuration files with Windows tools. For this, a freeware text editor called MetaPad was installed which could be configured to save with either Windows or UNIX line endings. Other than that, its look and functionality are similar to Notepad, with some added bells and whistles.

Content

Everybody that has used RADIANCE themselves will testify that the price which has to be paid for the flexibility and accuracy is a lot of time needed to get to grips with the software. This is largely due to the command line approach and the dozens of commands and hundreds of options. The time allocated within this masters course was half a module or 18 hours, excluding time for self-study. It is an unfortunate fact that this will only allow to introduce to the students the philosophy

Figure 2: The test cell.

RADIANCE is based upon (which is largely the same philosophy that has made UNIX such a successful operating system), as well as to make them familiar with the most basic commands and their usage. It was decided to only cover RADIANCE command line tools in the course. Although initially more difficult to learn, they provide much greater flexibility. Additionally, understanding how the software works makes the use of graphical user interfaces much more intuitive and allows for an efficient trouble shooting if problems are experienced.

From a previous project, a test cell existed on the balcony of the university building. It was used to carry out experiments with shading devices on an EC funded project and is now used for gathering weather data. It's a very simply construction in the form of a 2.5m cube with a slanted roof and an interior partition wall.

The simple shape of the pod lent itself to being modelled in RADIANCE. A log of environmental data was available, including vertical illuminance on the south facade and one internal illuminance reading. The data is recorded in minute intervals.

Figure 3: The inside of the test cell. During the experiments, the east half of the room was covered with black sugar paper.

For their assignment the students were asked to model the test cell as realistically as necessary and to produce virtual readings for the internal photo cell for two given dates. One of the days

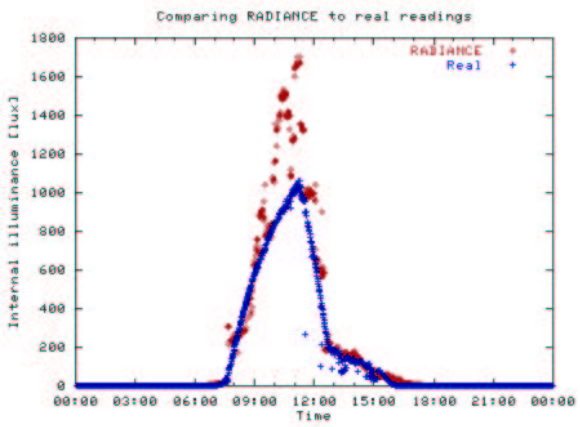

Figure 4: Plot comparing RADIANCE generated readings to real measurements.

was overcast, the other sunny. The results were then compared to the real data, and the students were asked to plot and discuss the results. A shell script was provided which took rtrace readings every 15 minutes over a period of 24 hours.

In general, the majority of the students quickly learned how to use RADIANCE and produced first simulations within a few hours. The simulations for the assessment was also no hindrance for most. All commands were known from the classes. However, where most of them struggled was with the plotting of the results. The environmental data was provided in minute intervals while the simulations were done every 15 minutes. The choice of an appropriate tool was left to the students. Most chose to use Microsoft Excel, only to find that plotting 1 and 15 minute data into the same graph is not as simple. Although explicitly required for the assessment, only two students in 3 years could actually deliver the required two plots. Both students preferred to hack the shell script in favour of writing Excel macros or using some other software such as gnuplot to which they were introduced in the class.

Conclusions

Computers running a version of Windows can easily be turned into X terminals allowing interaction with UNIX servers to deliver RADIANCE to a large number of students.

Operating RADIANCE on the UNIX command line proved to be rather unproblematic and straight-forward for most students. The proper use of normal office software was found to be much more challenging.