THE MAKING OF STATISTICAL FILMS

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1. Introduction

Since 1971 the Open University has offered courses leading to a first degree for part-time students who work from home rather than form a central campus. A typical undergraduate course involves 160 hours' study over a period of nine months, and twelve such courses (or their equivalent) must be passed before a student can obtain an ordinary BA; sixteen courses are required for an honours degree. The University's charter requires it to use a variety of different teaching techniques: as well as specially designed texts which are mailed to students' homes, many courses use television programmes broadcast nationally by the BBC. In this paper we examine the use of television in an introductory course on probability and statistics[1] which was prepared in 1982-83 and first made available for study in 1984. Section 2 describes the course and discusses some of the principles adopted for the use of television. In Section 3 we explain the methods used to prepare this material and highlight some of the technicalities which are involved, and in the final section we give examples from some of the programmes.

2. The Use of Television for Teaching Statistics

The Open University course M245, "Probability and Statistics", is intended as an introduction to the subject for students with a background in mathematics, and assumes basic skills in algebra and calculus. (There is another course for students who do not have this background.) The course starts by introducing the idea of probability in terms of long-term relative frequency, and goes on to define the binomial, Poisson and normal distributions. Inference is first introduced in terms of confidence intervals, and subsequently hypothesis tests and point estimation are described. The chi-square and tests are explained, and finally some aspects of Bayesian techniques are discussed.

As well as using printed texts, students of this course receive audio cassettes (which typically contained worked examples) and watch television programmes. There are sixteen television programmes in the course, each 25 minutes long; programmes are transmitted every two weeks from February to October. A simple calculation shows that watching television represents only 4% of the total study time for the course, and so it is very important to concentrate the use of this resource in areas where it will have the most effect.

In general we can identify two distinct uses of television for teaching this type of material. The first arises because statistics is a practical subject, and so we show practical demonstrations and applications. Sometimes these demonstrations are constructed artificially in our studios, replacing the lecture demonstration which would be found in a conventional university environment. Where possible, however, we try to show real-life applications using the techniques of location filming.

The second use of television is to teach the conceptual background to the subject in a dynamic way (here, "dynamic" is meant in a literal rather than a figurative sense). Our students have the disadvantage of studying almost entirely alone, so we use television to explain the theory in a more personal way and to provide moving images which can communicate the essence of a concept more succinctly than any verbal or symbolic description. These animations can be constructed as cartoons or, in many cases, can be generated by computer.

3. Preparing Television Programmes

Each OU course is written by a course team of University academic staff; where television programmes are used, there are also one or more television producers from a special department within the BBC. Typically, three members of the course team work together on each programme. After discussing ideas for the programme, they prepare an outline which lists the topics to be covered in sequence together with suggested television techniques for teaching those topics. This outline, which may be just two pages long, is then refined into a draft script of some twenty pages incorporating diagrams of visual material and a provisional text of the spoken part of the programme. At this stage designers start work on the graphical material (equations, diagrams graphs) which will be needed, and a final script for the recording is prepared. After all the material is recorded, it is edited together to produce a final programme ready for transmission. There may be slight variations to this schedule for programmes of different formats, but in general the entire process takes about three months.

For clarity, we should mention here the distinction between film, video and some of the other technical terms we have used. As far as the final product is concerned, "television" is a generic term for broadcast programmes, "video" refers to material on a cassette (e.g. VHS) and "film" refers to celluloid shown using a cine projector. However, in this paper we are more concerned with the recording rather than the final product; the output may have originated either on 16 mm film or on video (usually open-reel tape) or both, depending on the nature of the material rather than how it will finally be seen. We use film for a proportion of location work and for some types of animation, and video elsewhere.

Where graphics are used in a programme there are again several ways they may be recorded. When used in our television studio as part of a simulated lecture environment they are recorded at the same time as the presentation; demonstrations using microcomputers are recorded in the same way, although using an electronic signal directly from the computer rather than with a camera. Animations (which involve moving images) are generally

recorded one frame at a time: where iconic representations of non-mathematical concepts are needed, the images are prepared by hand and filmed; for other types of animation we again tend to use computers. However, microcomputers are generally not suitable for this kind of work, because their visual resolution is inadequate and because they cannot work fast enough. Instead we use a mainframe computer which controls a graphics display terminal and a videotape recorder. See Reference 2 for further details of this system. In particular, the animation described at the end of Section 4 was constructed using this method.

4. Some Examples

(i) The Poisson Process

A Poisson process may be characterised axiomatically. In order to give students a feel for the meaning of the axioms, and to show the type of situation where a Poisson model might (or might not) be valid, we included in this television programme a short film sequence showing four examples of events occurring over a period of time. The first example, free-flowing traffic along a major road, was an example where a Poisson model seemed appropriate, and the remaining examples illustrated ways in which the three axioms could fail to hold. When traffic was flowing along a congested road, the events were not independent; when shoppers entered a large department store there were multiple events (because many couples or families entered the shop together); and when bacteria reproduced by division the average event rate increased with time.

(ii) Sampling

In order to show some of the practical aspects of sampling, we included in this programme several film sequences showing quality-control tests carried out at a Coca-Cola factory. In particular, the final sequence shows how an official inspector uses a computer-generated list of random times to select fifty cans from the conveyor belt, and then weighs them to determine their contents. The computer attached to the weighing machine then calculates the mean and standard deviation of the sample. It also tests whether the population mean has fallen below the nominal level using a t-test with significance level 0.5%. This contrasts with the test used by the manufacturer, where the population variance is assumed known so that the normal distribution can be used.

(iii) Decision Tree Analysis

In the part of the course dealing with Bayesian techniques we wanted to use a television programme to show the way in which a practising statistician would tackle a typical real-life problem. To do this, we used a dramatisation with a fictitious electronics company and a problem involving the testing of printed-circuit boards. We also invited Professor Vic Barnett from Sheffield University to be filmed while performing as a consultant. Actors played the part of directors of the company, and we say the way in which the consultant would obtain data from the company and explain the consequences of different courses of action. As well as illustrating some of

the problems which occur in industry and require statistical techniques, the programme also demonstrated the use of Bayes' Theorem in this context.

(iv) Bivariate Distributions

In this programme we used computer graphics to show the density function of the bivariate normal distribution. Moving graphics can obviously be used to explain concepts where there is a natural development over time, but they are also valuable where a parameter can be changed continuously or where a three-dimensional object can be examined from different viewpoints. The animation used in this programme showed the effect of varying the correlation coefficient, and slicing the bivariate density to produce a family of conditional densities (univariate normal with identical variances) demonstrated by existence of a regression line.

References

1. M245: Probability and statistics (1984). Milton Keynes: The Open University.

2. Saunders, D.J. (1986). Computer graphics and animations for teaching probability and statistics. Int. J. Math. Educ. Sci. Technol., 17(5), 561-568.