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# Video Analysis and Repackaging for Distance Education

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*To*

*Dearest Gita, Kamal and Kirtana*

*ARR.*

*Raj, Shankar and all my teachers*

*SC.*

# Preface

The tertiary sector of our economy requires that a significant portion of the population be well educated. However, a vast majority of the population in developing and under-developed countries do not have a proper access to higher education. Higher education is expensive and, quite often, there are not enough qualified teachers in the locality. Education is a human-intensive training program and we require a very large number of well qualified teachers. Further, the progress in technology is very rapid today and our work-force is amenable to quick obsolescence unless we provide a continuous education program to the working professionals. This requires that we allot a significant amount of resources to our national educational program, which most of the countries are unable to do. As the demand for the higher education grows, so is the restlessness among the young generation to have access to quality education.

Fortunately, there has been a massive expansion in distance delivery and e-learning systems over the last decade. Many universities now offer their courses live to participants across the globe, and even offer complete or limited interactions with the instructor. Several e-learning portals offer video-on-demand services for specific courses. Many universities make their course materials available to the outside world for the benefit of all. One such laudable effort is the NPTEL program (http://www.nptel.iitm.ac.in) of the Government of India, that promises to make the entire curriculum of each of the undergraduate engineering programs freely available to the entire mass. Whether free or not, distance education does serve the purpose of enhancing the outreach of quality education to all.

Two important aspects of distance education are the quality of contents and the mode of delivery. It is imperative that the quality of contents be good, failing which distance education serves no purpose at all. The delivery of the content is also equally important as there should be no loss in the pedagogic value. A good quality video requires a significant amount of bandwidth for data transmission. In developing and other countries, the available bandwidth is still quite limited. This requires a significant reduction in data during the content delivery. Also, considering the fact that the penetration of mobile phones even in rural areas is very high, we should also explore the possibility of delivering the contents through the mobile display

unit. This puts a further constraint on the bandwidth during the transmission of the lecture video. Another added constraint is the limited size (resolution) of the display unit. One should be able to deliver the content on smaller display units without sacrificing the legibility of the contents.

The purpose of the monograph is to explain how one can enhance the outreach of distance education by appropriately repackaging the instructional video so that the amount of data can be drastically reduced without sacrificing the pedagogy. We have built a complete system that takes hours of classroom lecture video, processes it to generate a compressed representation of the data, called the instructional media package, and can play it on diverse multimedia platforms, including mobile phones. We believe that such a monograph is very timely as development of efficient distance education platforms is the need of the hour. We discuss various components of the system in full details with a view that practitioners of this area will be able to benefit from this monograph.

This monograph is an outgrowth of the Ph. D. dissertation work of one of the authors under the guidance of the other at the Indian Institute of Technology Bombay. The book is a revised and extended version of the thesis. Several of the ideas presented in the monograph are quite novel and have been filed for patents. A fully functional android platform based media player, called *Lec-to-Mobile*, has been released to the public in 2011 and is freely downloadable form the android market site. We recommend that the readers use this player on a mobile display unit for a better understanding of the discussed topics.

This monograph may be of value to video analysis researchers and practitioners who are interested in developing technologies for video analyses in general, and educational video in particular. The book is mostly self contained and is intended for a wide audience. The mathematical complexity of the book remains at a level well within the grasp of undergraduate students. A basic familiarity with the area of image processing should suffice. Hence the students may find this book useful as a reference. We have provided a large number of figures to help understand the topic well.

We welcome comments and suggestions from the readers.

Mumbai,
January 2012

*A. Ranjith Ram*
*Subhasis Chaudhuri*

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Mumbai,
January 2012

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# Media for Distance Education

## 1.1 Introduction

Education can be thought of as the process of adding value to life. Apart from its fundamental goal of gathering knowledge, it has manifold long term objectives. One may say that education focuses at (i) value creation, (ii) economic viability, (iii) broadening of perspective, and (iv) enhanced social outreach. It should help an individual mold his/her personality, earn a living, which in turn accounts for his/her social health and lifestyle. It is hard to define the efficiency of educational systems from the value creation point of view since objective measures of value are not possible. In order to devise some means to quantify the efficiency of education, it would have to be treated more like a commodity rather than an abstract concept of knowledge. In this aspect, educational systems may be modeled as commodity markets whose performance measure is given by the throughput of the system. We define the throughput to be the average number of students graduating per year per instructor for a given curriculum.

A quick tour on the evolution of education systems would be helpful to note how their transformation has affected the throughput over years. About 3000 years ago, the education system was based on *gurukula*, which means the extended family of the *guru* (teacher) wherein the students reside until graduation, help performing the household chores and learn from the guru. It did exist in India, China, Japan and Greece in which a disciple was resident with his/her *guru* or teacher. That is, the school was primarily residential in nature in which all students entered at a lower age, lived with their teacher and left the school when the education was deemed to be complete. Both the admission and graduation processes were asynchronous in nature. The disciple learnt everything from his/her *guru*, including the day-to-day needs like cooking, washing cloths, and handling weapons. As per the education model already mentioned, this system could be thought of having a single *vendor* (one *guru*) and multiple *customers* (M disciples). The period a particular student had to spend in the *gurukula* to graduate depended on the competence of the student as well as the process of instruction followed by the guru. The throughput of such

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a system could be assumed to be about 0.5 in the absence of any appropriate documentation. Hence on an average, one student graduated every two years from a guru and this is naturally quite low. However, given the nature of the economy in those days, this was probably good enough as the tertiary sector of economy was yet to arrive.

Around 1000-2000 years ago, there evolved *universities* as port-folio managers in education. The examples of such a system are Taxila University and Nalanda University, with which N *gurus* and M disciples were associated. Again the throughput was found to be almost similar, but with the possibility of providing a better domain knowledge since a student is in touch with multiple teachers under the university during the graduation process. The scenario changed very much from $14^{th}$ century onwards due to the advent of well structured university systems in Europe. The same model of education was driven by renaissance and industrial revolution. Technology evolved as a subject in these universities during this era. Also gradual streamlining of the university system took place and the throughput could be increased beyond 2.0[1]. The teacher to student ratio slowly increased to about 1:10.

After 1990, there was another noticeable change - the model remained the same, but with a more information dissemination capacity. The key facilitator was the Internet and the associated digital technology, by which the outreach of education is drastically increased. There evolved a *distance education system* and the teacher to student ratio could be further increased up to 1:30. One could attain an enhanced system throughput of greater than even 5.0 in some of the universities now. For example, at Indian Institute of Technology Bombay, the throughput is currently 3.0 while in Europe and in USA, some of the non-research intensive universities have attained a throughput as high as 6.0. Lately many of the universities are also experiencing financial difficulties due to reduced or limited state support and the universities need to enhance the throughput for better financial solvency. But how does one increase the throughput? The answer possibly lies in how efficiently we can enhance the outreach of distance education.

## 1.2 Distance education and e-learning

We have explained the need for distance education in the previous section by substantiating the increase in throughput while extending education beyond classrooms. With the proliferation of various new technologies in the field of distance education, the concept of *teaching* and *learning* has undergone revolutionary changes in the last one decade. In this aspect, real classrooms are being augmented or even replaced by an e-learning environment. With this, a student can use a computer and communication networks for off-classroom learning. Recently many distance education providers also came into picture, who either perform a live tele or webcast of the class room being taught or supply the DVDs of the

[1] Data in support of such a number is not available. The authors used their subjective judgment to arrive at the numbers.

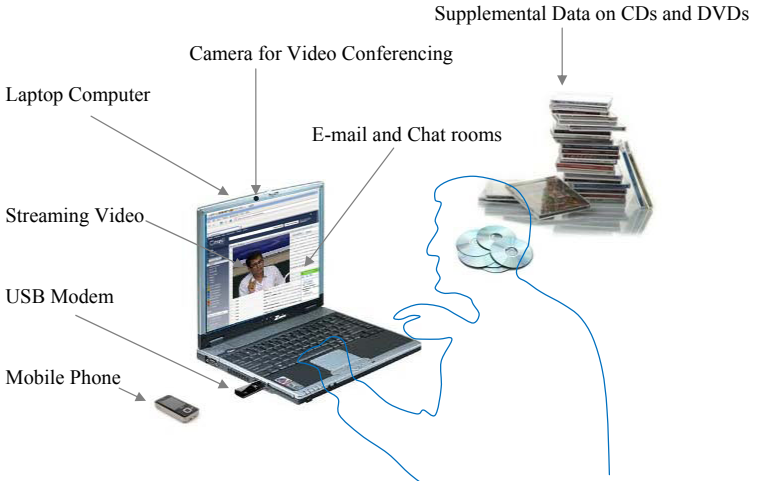


**Fig. 1.1** A diagram showing the different technology interfaces used by a student in an e-learning environment.

stored lecture video or maintain video on demand for different courses. Examples of such educational systems are the Distance Education Technology and Services (DETS, website: http://www.dets.umd.edu) by University of Maryland, Division of Continuing Education (DCE, website: http://www.dce.ufl.edu) by University of Florida, School of Continuing and Professional Studies (SCPS, website: http://www.scps.nyu.edu) by New York University, the Open University in U.K. (website: http://www.open.ac.uk), Centre for Distance Education (CDE, website: http://distance.uaf.edu) by University of Alaska, and Centre for Distance Engineering Education Programme (CDEEP, website: http://www.cdeep.iitb.ac.in) by IIT Bombay.

Now-a-days the Internet also provides an effective means for web based education and infotainment. The student can also attend examinations *online*. Examples of such educational systems are Stanford Engineering Everywhere (SEE, website: http://see.stanford.edu) by Stanford University, Distance Education Network (DEN, website: http://den.usc.edu) by University of Southern California, Northeastern University Online (website: http://www.northeastern.edu/online), University Extension of the University of Texas at Austin (website: http://www.utexas.edu/ce/uex/ online), Boston University Online (website: http://www.bu.edu/online), and Arizona State University Online (website: http://asuonline.asu.edu). The spread of such educational systems have opened up new dimensions on teaching and learning processes such that a student can use the learning aids *anywhere, anytime*.

A typical e-learning environment is shown in Fig. 1.1. The student is in interface with the knowledge world through a laptop computer equipped with Wi-Fi LAN and through cellular telephony. Here the pedagogy is effected entirely by electronic means, and hence is the name *e-learning*. User can browse the Internet, participate in a video-conference or play video on demand on the Wi-Fi networked laptop.

IP telephony can also be effectively utilized by the student for knowledge sharing. Through the technologies like GPRS, Wi-Fi, 3G and beyond, the cell phone would also provide the student an efficient means for distant access. Apart from these, he/she can also employ the laptop for watching the supplemental material on the CD-ROM or DVDs which are provided by the distance education centers. One can also utilize many of the online learning platforms available. For example, in India, for distance learning students can effectively use the A-VIEW® (Amrita virtual interactive e-learning world) tool by Amrita Vishwa Vidyapeetham. Further, supplemental e-learning can be effected through NPTEL (National Programme on Technology Enhanced Learning) run by IITs and IISc, and AAQ (Ask A Question) run by IIT Bombay. These electronic means are found to be very efficient and attractive in the dissemination of knowledge.

The quality of education always lies in two factors - (i) the depth of knowledge of the teacher and (ii) the effectiveness of dissemination of his/her knowledge. The first factor is absolute and crucial but the latter in turn depends on several aspects like (a) quality of oration, (b) quality of board work, (c) effective interaction with the students in the classroom, and (d) the body language. As we have already explained, the advancements in communication technology have largely contributed to the both ends of knowledge sharing - *teaching* and *learning* during the last few years. Consequently the outreach of education has been extended from the classroom to distant places so that the accessibility of knowledge centers has improved. For such augmented learning methods, video is found to be very powerful due to its inherent ability to carry and transmit rich information through its constituent media.

Digital video is a versatile media with applications varying from entertainment to education. It plays a major role in constituting a knowledge database, irrespective of the domain of usage. The information contained by the digital video is conveyed to the end user by the visual data present in the video frames along with the associated audio stream. This accounts for a high bandwidth requirement for video transmission. The visual patterns present in image frames usually contain a large amount of redundant information which bring about another limitation of a large memory requirement. Therefore the price paid for the efficiency in conveying information by video includes both memory and bandwidth. Hence the content analysis of digital video by which it can be represented in a compact form is inevitable for its easy access and fast browsing. In the present scenario of the increased use of communication networks and the Internet, the research and development of new multimedia technologies which aim at structuring, indexing, summarizing, meta-data creation and repackaging, would really contribute to the field of infotainment. Our effort in this monograph is to suggest how these tasks can be achieved. To start with, one should study the organization of a digital video and the related nomenclature first.