ISTITUTO DI SCIENZA E TECNOLOGIE
DELL'INFORMAZIONE "A. FAEDO"

Short Term Mobility Report
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Submitted to CNR and
Shanghai Jiao Tong University, Image Communications and Information Processing Institute

This research visit had the objective of developing research collaboration between ISTI-CNR and Shanghai Jiao Tong University, Image Communications and Information Processing Institute in a number of topics which can be listed as:

- Data compression for impulsive sources
- Design of optimal encoders for data compression
- Bayesian learning for human tracking in computer vision
- Reflection cancellation in videos

During my visit, I also gave a seminar on our research activities in ISTI-CNR on the topic of component separation in images with title: "Planck Satellite Mission: the Component Separation Challenge". The seminar was followed by a group of 30 researchers and students and received enthusiastic interest. The seminar led to the discussion of new research directions afterwards with a number of PhD students and their supervisors.

The research activity can be summarised as:

1. Data compression for impulsive sources:

Heavy-tailed or impulsive phenomena abound in many real life applications. It has been demonstrated that various signals such as urban images, financial data, geophysical signals, teletraffic data and web-related data demonstrate impulsive and skewed characteristics. In particular, it has been observed by various researchers that the wavelet coefficients show heavy tailed characteristics and suggested multivariate Laplace distributions, generalized Gaussian distributions and alpha-stable distributions. Tsakalides and Nikias suggested a special case of stable distributions namely Cauchy distribution and indicated a number of open problems for the study of source coding systems for heavy-tailed distributions. Among these distributions, alpha-stable distributions have gained a wide acceptance in fields ranging from teletraffic analysis to radar signal processing. Unfortunately, to the best of our knowledge, there is no work on studying the source coding properties of alpha-stable distribution and its rate distortion function. It is of fundamental importance to develop the rate distortion function of alpha-stable distributions which would give us its limits in lossy and lossless source coding. In particular, the rate distortion function can help us in the design of more realistic source coders. We developed the rate distortion function for alpha-stable distributions using the Blahut algorithm. The results are shown in the below figure.

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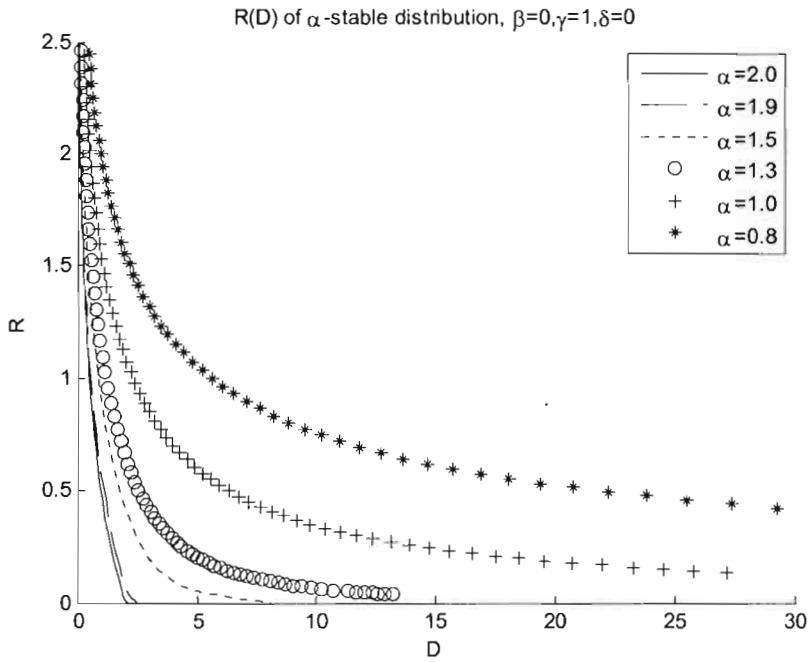
This is the first result on the rate distortion function of alpha-stable functions in the literature and will be very useful in the design of lossy source coders for alpha-stable or impulsive sources since the R(D) curve provides the bounds on the source coder performance and based on this information realistic goals can be set. One important result is also the observation that for the same distortion level, for smaller alpha value that is for more impulsive distributions, one needs higher rate compression.

This research is carried out with Dr Jia Wang and his student Tao Zhou. A paper is propared during the visit and will be submitted to IEEE Communications Letters.



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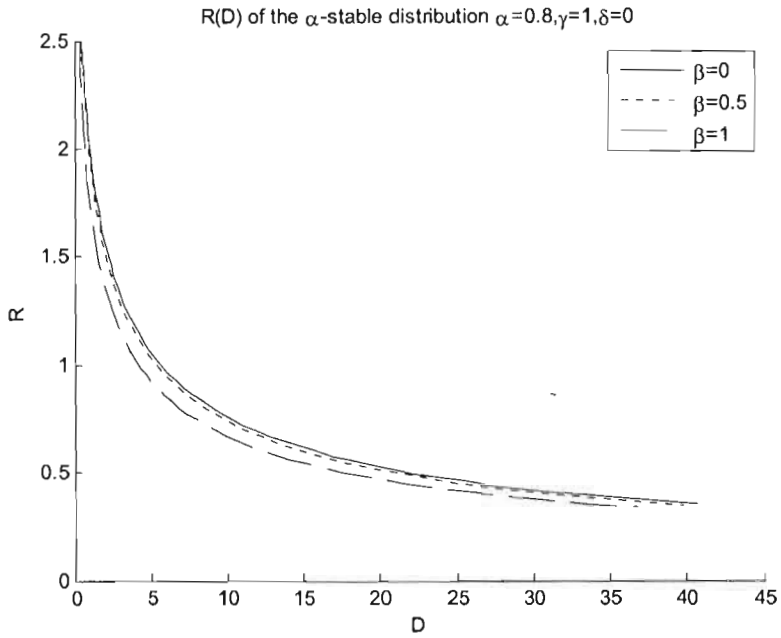

In the continuation of this research, using the same methodology (Blahut Algorithm) the channel capacity will be calculated for alpha stable noise channels. Various recent communication technologies such as mobile communications, satellite communications and xDSL, defy the Gaussian channel assumption since they operate under impulsive noise channels. These channels are characterised by sudden bursts of noise which have high amplitudes frequently surpassing signal amplitude. Traditional communication systems are designed under Gaussian channel assumption and the channel capacities developed with this assumption are not valid for impulsive channels. In the literature, many wireless communication channels are modelled with alpha stable distribution. With the channel capacity, one can design better wireless architectures and communication protocols. Moreover more realistic buffers can be designed avoiding significant packet loss.

2. Design of optimal encoders for data compression

In this work, we are interested in data compression systems with memory,, i.e. based on trellis structures. In data compression or source coding systems, the system is composed of two main parts: encoder and decoder. The encoder is generally an optimal search algorithm such as the Viterbi algorithm for trellis encoders. The decoder is composed of two parts: codebook and next-state transition map. The codebook is designed by techniques such as the Generalised Lloyd algorithm. The next state map is generally not optimised and is assumed fixed. In this work, we aimed at designing optimal next state transition maps. We use a finite-state machine

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for the transition maps, ideal for describing trellis structure. In this work, we show that the performance of trellis coders is very much dependent on next-state map. Furthermore, we show that adaptive design significantly improves performance for non-stationary sources.

This research was done in collaboration with Dr Jia Wang and his student Jue Wang. A paper was written during the visit which will be submitted to IEEE Transactions on Image Processing.

3. Bayesian learning for human tracking in computer vision

Standard Hidden Markov Model (HMM) and the more general Dynamic Bayesian Network (DBN) models assume stationarity of state transition distribution. However, this assumption does not hold for many real life events of interest. In this work, we propose a new time sequence model that extends HMM to time varying scenario. The time varying property is realized in our model by explicitly allowing the change of state transition density as the time spent in a particular state passes by. Rather than keeping these transition densities at different time spots independent of each other, we exploit their temporal correlation by applying a hierarchical Dirichlet prior. This leads to a more robust time varying model, especially when training data are scarce. We also employ Monte Carlo Markov Chain (MCMC) sampling in learning the MAP estimate of time varying parameters, with a transition kernel incorporating linear optimization. The proposed model is applied to recognize real video events, and outperforms the existing HMM-based methods. We emphasize that the contribution we made on Dynamical Bayesian Network estimation is applicable in various applications. This work can be considered as the continuation of the research we started last year and already submitted a paper to the journal: Machine Learning.

This research was done in collaboration with Prof Xiaokang Yang, Dr Yu Xi and their research student Ma Liang Yang. The specific problems we consider are tracking of occluded objects in videos.

4. Reflection cancellation in videos

Reflections from windows and other shiny surfaces create an important problem in video sequences. For video for leisure applications, user would like to avoid any reflection from windows while they are registering a video. In security applications, reflections prevent correct recognition of subjects.

A recent paper by Kayabol and Kuruoglu proposed a method which utilizes colour information for reflection cancellation from still colour images. Our work aims at extending this work to video sequences and utilize also motion information. We foresee important industrial

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applications of this problem. In this work I am collaborating with Prof Xiaokang Yang and his student Qing Yan.

Other activities

I was invited by ***Shanghai Electricity Company*** to visit their Research and Development Center in Shanghai. I was received by the vice director of the centre and I had a meeting with the group responsible for Wind Power technology and made an agreement to develop our communication with the aim of starting formal collaboration in the field of wind power forecasting.

Final issues

This trip has given me an opportunity in developing important applicative research ideas. It has been agreed to look for other types of funding outside CNR and SJTU that can lead to a collaboration on a bigger scale and possibly bring benefits to CNR and SJTU. The Image Communication Institute recently obtained a government project funding for video archive restoration and another project funding for Social Network Processing. It has been agreed to collaborate also in these projects in 2010. In the video archive restoration project the third partner will be Trinity College Dublin with which we already had collaboration in the MUSCLE Network of Excellence (6^{th} framework project).

I was hosted in an excellent way by the Shanghai Jiao Tong University. They provided me very good facilities for working and for accommodation. I would like to thank them very much for their hospitality.

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