Research Projects

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Additional Research Projects

An outline of my research can be read in a different attached document, titled "Research Statement." On it, I summarize the main lines of investigation in which I have been professionally involved in the last four years. The decision of focusing on those topics was always heavily influenced by the group of scientists with whom I teamed up, but mostly by the leader of said team. The same figures that inspired and guided me as a scientist, did also spark the pleasure of passing this knowledge toward those students following our steps. I had the privilege to learn a great deal of people's management from talented and brilliant mathematicians, chemists, physicists, computer scientists and engineers, and I aspire to bring that experience into an undergraduate research group of my own in a near future.

In that sense, and following the ideas behind my main research line, I started the planning of several possible ways to interact and engage undergraduate talent. The following is a brief summary of such a project:

Art Authentication. Vincent Van Gogh died in 1889 poor and unknown. He was an avid painter but lacked of organizational skills and any cataloging interest. He would take any opportunity to sketch and paint, but after he was somewhat satisfied with the result, he would store his production and forget it in the mess that was his studio. Often, most of his sketches will end up in the property of friends and acquaintances, that would keep them as a memento of their friendship, or as a token of appreciation for a service to the painter. Van Gogh's immediate family inherited the majority of the master's production after his death, and these few hundred pieces went unnoticed for several years until a group of very enthusiastic French painters "discovered" the genius behind the style of the Dutch master. In the following five to ten years, his originals started being acquired by art dealers and museums, and the momentum was so great that thirty years after his death, in the 1920's, his paintings were already among the most expensive in the World.

Many art dealers, second rate painters and museum owners saw the opportunity to profit from the lack of a catalog of Vincent's opus, and very many *new* Van Gogh's arose. An army of art experts would face the problem of establishing the authenticity of these new pieces, but often the financial interest of both experts and museums would cloud the truth and admit as authentic a fake.

In the late 1990's the Project Van Gogh was born, as the first exponent of the so-called "Scientific Art Authentication": a set of mathematical and computational

techniques destined to explore the **dating**, **authorship** and **description of features** of any given painting. This is an example of multi-modal research where Chemistry, Mathematics, Computer Science and other material sciences interact with Statistics to answer any and all of the three questions posed above.

One of the most important aspects in art authentication starts from the extraction and study of the brush-stroke technique used on a given picture. And here is where the field of Approximation Theory (and especially the use of the Curvelet or Shearlet frames described in my early work) has its impact. We know that any given image, once digitally rendered, can be represented in very many different ways: as a collection of pixels, or as a collection of coefficients in some other smart basis or frame (wavelets, Fourier, Gabor, curvelets, etc). The advantage of representation in a frame like the curvelets is in the fact that each coefficient offers certain information that can be exploited to better understand the characteristics of the image at a given location in the canvas, in a given direction, and at a certain scale—a brush-stroke! This allows quick computer codes to decide statistical properties of the artistic technique of a given painter, for example, or the possibility of comparison of the technique on two different paintings.

While most of the theory behind Curvelets is only accesible to experienced mathematicians, the implementation of the decomposition of a given image by curvelets coefficients is easy to code for anybody with enough knowledge of computer programming and familiar with the techniques of Vector Calculus. A group of students with the right background would have surely no trouble to implement, for example, a set of applications for a device with camera (such as an iPhone, iPad or an Android-based device). Such a program captures a painting with the camera, or from a sufficiently good image online, and would be able to perform basic brush-stroke analysis of the object in a matter of seconds.

A group of students would need no more than the necessary funds to code, test and publish these applications, reporting the scientific knowledge acquired to a scientific document or a poster, and funding to travel to meetings to present their research.

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