Quantitative Analysis of Questioned Documents Using an Atomic Force Microscope

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Abstract:

The goal of this research is to examine the atomic force microscope (AFM) as a tool for the quantitative analysis of questioned documents in order to be able to detect forgeries. This research has potential to provide detectives with another invaluable tool to identify potential forgeries and investigate other forensic evidence.

Introduction:

An atomic force microscope uses an extremely small probe to feel over a surface, and then creates a 3D digital image that can be magnified up to 100,000,000x. A normal light microscope can only magnify an image several thousand times. An atomic force microscope creates an image by running an extremely small probe over a surface so that it moves up and down as it goes over the various bumps in the surface. It then measures the vertical movement of the probe with a laser to calculate the height, so that a three-dimensional image can be formed. The probe itself is extremely small, and most are generally less than 10 microns long (1 meter = 1,000,000 microns) and at the very tip are only an atom wide (the diameter of a hydrogen atom is around one nanometer, or one one-billionth of a meter). Besides the extreme magnification, another benefit of the atomic force microscope is that sample preparation is very simple. As long as a sample is small enough to fit in the microscope, it can be immediately ready for observation. This means that the sample does not need to be disturbed or manipulated, and the purity of the sample can remain intact [1].

The atomic force microscope was invented in 1986. Currently, atomic force microscopes are being used in many different fields including analysis of atoms and the surfaces of different metals and compounds. They are also being used to analyze biological samples in order to generate more accurate representations of very small things. There are still many other potential uses of the AFM by researchers who want to analyze microscopic or near-microscopic samples.

Current methods for analyzing questioned documents, or potential forgeries, are very subjective, and there is little science to fall back on. The best document analyzers look at known originals from an individual, and then compare them to the questioned documents to see if any inconsistencies can be seen. This method is inherently flawed because it relies on a person to notice any differences between samples using very basic tools such as magnifying glasses and optical microscopes [2]. These methods are not perfect and there is still reasonable chance that an analyst could make a mistake. With enough practice and skill, an exact visual copy of a writing sample could be created, but one thing that is unique to every person is the amount of pressure used to actually create the writing. While current document analysis allows for detection of visual imperfections, there is no current method to determine the pressure used to create a sample. The atomic force microscope however is able to actually measure the height and width of a line written on a piece of paper, and is also able to calculate how much pressure was needed to create the line. So in theory, an atomic force microscope could be used to measure a known writing sample and a potential forgery, and would be able to quantitatively state if the questioned document is in fact a forgery [3].

Results and Discussion

As a result of this research project I gained a very thorough understanding of how the atomic force microscope works, and laid some very important groundwork that is essential for continuation of this project.

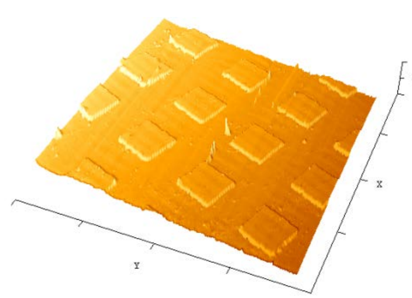

Fig. 1: A scan of the optical reference with the training probes.

The first few weeks of the project were devoted to training on the AFM. Following that, samples were obtained by writing the letters "i", "j", and "x" on *Staples* glossy paper with a *Bic* "Round

Stick" ballpoint pen. These letters were chosen because both the "i" and "j" have the dot at the top, which was of interest during the research, and the "x" had a cross which also posed interesting opportunities for experimentation. Glossy paper was chosen because the fibers were very tight and close together, which minimized the amount of ink that bled into the paper, and would leave the ink slightly raised. All three samples were obtained from the same author using the same pen. After the three samples were collected, they were prepared for AFM inspection by attaching them to glass slides using double-sided tape. The entire slide was then taped to the sample holder, and was placed in the machine. The purpose of the glass mount was to provide a solid surface for the sample to be mounted on, as well as making removal and storage of the sample very easy.

At this stage I encountered my first significant challenge. It was anticipated that gold-tipped probes would give a better reading. However, the probes were not mounted to the appropriate magnetic strips by the manufacturer in order to attach them to the microscope. The probes had to be glued by hand to the magnetic strips. Through this manual process, I was not able to mount the probes as perfectly as was needed, which resulted in either incorrect scans or not being able to produce scans at all. After consulting with Dr. Sinha, an automatic probe-mounter was ordered to eliminate the human error in the situation. Unfortunately, the probe-mounter did not arrive in time to complete the experiments prior to the end of the summer program.

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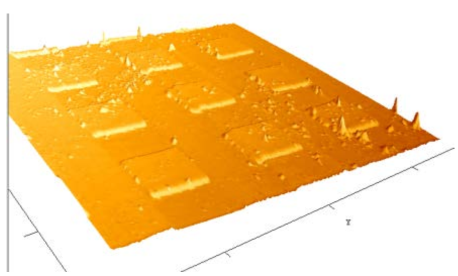

Fig. 2: A scan of the optical reference with incorrectly mounted probe.

Conclusions:

Although the original goal was not reached, which is not uncommon in scientific research, some very important work was done in paving the way for analyzing handwriting using atomic force microscopy. Learning how to use the atomic force microscope was invaluable for me as I continue my career in scientific research. Learning the process of gathering and mounting the samples was very useful and I will incorporate it into future research.

With more time and resources, the research seems very promising. As research continues, additional letters could be analyzed in order to identify those alphabets that work best for this application. Testing different pens and papers would be of interest as well as testing the same person's handwriting of the same letter with allowing a period of time between the collections of samples.

While AFM document evaluation has potential to serve needs of law enforcement, it also could be applied in fields such as the forensic analysis of art as well as being used for other novel applications.

References:

1 West, Paul. AFM University. 2007. Pacific Nanotechnology. 1 Apr. 2008 <http://www.afmuniversity.org/>.

2 Ellen, David. *Scientific Examination of Documents: Methods and Techniques*. Boca Raton, FL: Taylor & Francis, 2006. Print

3 Huber, Roy A., and A. M. Headrick. *Handwriting Identification: Facts and Fundamentals*. Boca Raton, FL: CRC, 1999. Print.

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Biography:

Gregory Bode is currently a junior majoring in chemistry and forensics with an emphasis in chemistry. He hopes to go on to pursue a Ph.D. in chemistry from a college in the northeast and work in a laboratory either doing research or synthetic chemistry. He is also currently doing research in the field of carbohydrate synthesis.