Forensic Evidence Management Information Systems (FEMIS)

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Abstract

The Forensic Evidence Management Information System (FEMIS) is a web based system that houses data on a centralized database in order to store all forensic evidence in one receptacle. The forensic evidence may include pictures of suspects, fingerprints, handwriting samples, etc. Law enforcement agencies will have the ability to enter a new case with all relevant evidence and enter a description of the data. The agencies will also have the opportunity to search for existing cases and forensic evidence attached to that case. The focus of this study is to produce a database system that will allow all evidences to have a common link, thereby allowing various agencies to obtain needful information. The proposed database will keep track of who has handled the evidence in order to reduce the risk of mistrials related to evidence tampering or evidence gone missing.

1. Introduction

The investigation of a crime scene can be an agonizing one. It can yield leads towards the assailant as well as clues that indicate how the offense took place. The investigator(s) are faced with the mammoth task of collecting as much evidence without overlooking anything. Once the collection is complete, tracking the evidence through the course of the investigation which may be weeks, months and sometimes years, is vital towards getting a conviction. It is for this reason that collecting and tracking information is crucial towards the investigation.

Local law enforcement agents are faced with having limited resources and computer training and are customarily the first to be involved in an investigation. Federal law enforcement agencies and forensic laboratories have various proprietary systems within their organizations. These systems rarely, if ever, interface with each other and the same data can be input into the individual systems numerous times. FEMIS is an effort to develop one system that may be used by all the agencies and provide ease of use to all. Working with the Pace University’s Forensic Science Department and using their resources and data, the CSIS Department can develop a system that is secure, requires minimal computer expertise, and will potentially interface with existing systems.

It is the desire that one day FEMIS can prove to be secure enough to be accepted by law enforcement agencies. This will bring together the combined effort of many systems that already in place to expedite the time that it takes for an investigation to be ready for court. Some of the efforts would include but are not limited to reviewing photos and accurately assessing the environment of a crime scene and pulling data throughout the country and expeditiously pinpointing suspects. At this time, FEMIS, serves as the initial platform necessary to pull all the data necessary to bring this effort to fruition. Its use is primary for educational purposes and may be used by the Pace University Forensics Lab in order to provide a virtual environment for the technician’s to look at their evidence in a holistic manner. The challenges will include collaboration with other existing systems that are discussed further in the paper and also acceptance by law enforcement agencies due to security reasons.

1.1. Information

Various types of information gathered at the crime scene such as the investigators journal and or photographs. This information gives great insight towards the understanding of each case on a deeper level in order to solve the case. With the focus on forensic evidence, FEMIS also manages the photographs taken at the crime scene as well as all notes logged by investigating officers. FEMIS offers investigators a different approach to managing cases in order to have the information on the case readily available to permitted officers. Having such information ready in one database will undoubtedly play a significant part in bringing these criminals to justice on a much shorter scope than it would take otherwise.

1.2. Project Goals

The goal of this project is to assist in reducing the time that it takes to produce results of forensic evidence
analysis. The labs are faced with being understaffed for the amount of evidence needing analysis and the law enforcement agencies are faced with an overwhelming amount of evidence. An old city, such as New York, for example, may have forensic evidence on open cases dating back to the 1900’s. Evidence is never discarded as new and undiscovered techniques for evidence reviews is constantly evolving. FEMIS will help to ensure that evidence is properly tagged and managed and all relevant personnel have immediate access to all information. This effort will assist in future handling of evidence. The efforts entailed in retagging all existing evidence may prove too great for law enforcement agencies. The evidence needs to be collected by field agents and then tagged and brought in where it can be disseminated accordingly. If the field agents have the ability to pre-log all evidence while out in the field, the evidence detectives and district attorney’s office will be able to make pertinent decisions on the case in a matter of minutes.

2. Forensic Evidence Management Information Systems (FEMIS)

FEMIS has been created in order to give investigators purpose into an organized atmosphere that will help solve crime(s). The system helps to map out just how much evidence is obtained, what is obtained and the detailing of each item. Currently law enforcement officials of the Mt. Vernon Police Department gather evidence and tag it by hand out in the field. They bring the evidence to their respective agency where the evidence is logged into their agencies local database. If a request is made for the evidence to be analyzed by a forensics lab, the information is then logged into the lab’s database system and the evidence is sent to the lab. Westchester County’s Lab has a system called the BEAST, where the evidence detective is able to pre-log the forensic evidence he sends to the lab.

It simply is not enough that evidence is gathered and analyzed at a later time. With the number of case loads law enforcement agencies are faced with and the vast number of evidence collected, labs are only analyzing forensic evidence that the DA Office is requesting. As time is of the essence, it is greatly imperative to group these items together creating a frame of reference for these investigative officers.

Additionally, FEMIS takes the process of database organization a bit further. The system will be optimized in order for investigators to pre-log all evidence at the crime scene on mobile devices. The evidence detective has the ability to review all data entered prior to the evidence even making it to the agency. Further, for cases that are clearly violent crimes such as a murder, the DA’s office can immediately request that evidence pre-logged on the field be sent directly to the lab. This will decrease the time that it takes for results of evidence to be evaluated. FEMIS will allow only a limited amount of investigators as well as the medical examiner to log in with full access. Doing so will permit a very narrow window for error and help to keep the evidence safe from tampering.

Having the ability to log all results in FEMIS all authorized personnel from any agency/department quick access in order to review and compare the results. This will help create connection with prior cases more easily. Analysts will be able to create links between crimes easily and spot patterns between new crimes and old solved/unsolved ones. These similarities and links play a key role in catching criminals who may have eluded justice for long durations. Every crime scene may bring investigators a little closer to their goal of catching the one responsible.

Interviews with the Mount Vernon Police Department and the Westchester County Forensics Lab revealed that all known DNA must first be positively eliminated as a possible suspect, including that of the victim, relatives, friends, an officer or forensic investigator. Once the unknown sample has been correctly isolated, it is then compared to the genetic database with the hopes of finding a positive match. If the DNA results do not match existing DNA on the Lab’s or FBI’s DNA database, CODIS, it will then be added as belonging to a possible suspect. A link can now be determined if the DNA were to appear in a future crime scene.

Collected evidence consists of, but is not limited to; fingerprinting, photos, officer’s journal, blood samples, various drug testing, ballistics, firearms, shell casings, fibers, hair, in addition to any other forms of evidences that are found at the crime scene. FEMIS holds information on all potential and pertinent personnel to any case. This includes crime investigators and their agencies, lab technicians, their credentials and labs they are associated with and district attorney’s offices. The information relevant to all personnel contains, but is not limited to, name, date of inspection, investigators rank and all credentials and certifications.
In order for this process to work as seamlessly as possible, however, the evidence (once retrieved) is labeled using an evidence label.

Doing so reveals information such as:

- Description of item
- Name of person(s) whom collect the evidence
- Time, date and location of collected evidence
- Unique or unusual identifier of evidence

### 2.1. Database

FEMIS is built on the MySQL database platform in order to track the various pieces of information including the aforementioned DNA & Blood (result), fingerprinting, journals and photos. Using this system will give us a stronger grasp on obtaining what is needed and make it duly available to those that have access. Additionally MySQL is a low level language that is easy to implement and teach to others. Law Enforcement agencies all have IT departments that can additionally extract information beyond the reports that this team is designing.

A login id is required for all to use the system. In order to prepare FEMIS for use, the law enforcement agencies need to be added to the system as well as all the law enforcement officers/agents. Likewise labs using the system need to be added to the system as well as the technicians working in the labs and their certification information. When a case is created, there will be a lead officer assigned to the case, as well as all the case officers. The labs will be assigned to each piece of evidence in the case that evidence needs to be sent to specialized labs.

Information for the suspects can be created from the case screen as well as all the evidence information. Another table that we have added is the authorized dwellers table. This table reflects people that were authorized to be at the crime scene and that are not suspects. This will help agents to eliminate their DNA, fingerprints or authorized weapons as the suspect(s)’.

Tracking the chain of custody for every piece of evidence is the most crucial part to any investigation. Once the item(s) are taken from the crime scene for further examination, it is placed into a holding case (which may be refrigerated if necessary) for preservation. Every time a piece of evidence changes hands, it is of the utmost importance that the chain of custody is updated. If this procedure fails at any given time during an investigation, that evidence is considered tampered with and inadmissible to the court. The primary key of chain of custody table is made up of the date and time stamp field and the evidence id field. The table also tracks which officer or technician is currently in control of the evidence. This table should be updated to house digital signatures.

Currently, the FBI CODIS database that houses DNA information on criminals and suspects is on a separate and secure network that the FBI will not allow other networks to be tied into. We show a dashed line to the CODIS database as well as to FBI’s Integrated Automated Fingerprint Identification System (IAFIS) database in hopes of future connections.

The tables and fields in the system currently are:

- **Login**: (loginid, psswd, lname, fname, auth_level)
- **Cases**: (cs_id, leadoff, status, add1, add2, city, state, zip, descr)
- **Officer**: (off_id, fname, lname, title, loc_id)
- **Cases_Officer**: (cs_id, off_id)
- **Agency**: (loc_id, add1, add2, city, state, zip)
- **Lab**: (labid, tech_id, specialty, add1, add2, state, city, zip)
- **Frms_evid**: (ev_id, recvmethd, type, col_off, col_dt, detct_method, lab_id, results, matchDNA, due_dt, location_fnd, address, city, state, zip, case_id)
- **Firearms**: (sn_id, make, model, results, location_fnd, lab_id, seiz_off, address, city, state, zip, case_id)
- **Cases_Firearms**: (cs_id, firearms_id)
- **Photo_evid**: (photo_id, ph_dt, method, descr, lab_id, coll_off, case_id)
- **Cust_chain**: (dt_tm, item_id, off/tech, case_id)
- **Auth_dwellers**: (auth_id, lname, fname, relation, add1, add2, city, state, zip)
- **Known_forensics**: (know_id, donor_id, dna_results, print_results, blstics_results)

The ER Diagram shows the relational database that has been developed.
2.2. System Development

We have chosen to link MySQL via servlets. Doing so allows access to the FEMIS system to run across various platforms such as Mac, Linux, and Microsoft. Moreover, the system has been implemented with security in mind and thus direct access to internal pages through URL manipulation would be impossible. With that in mind, the FEMIS system will not tolerate SQL injections such as empty double quotes and or using quotes or double dashes for the username and password.

We have done our best to make sure that the system interface is friendly and accessible. Additionally, FEMIS allows the every authorized user to access and navigate throughout the system without any previous knowledge of databases and or MySQL.

Challenges faced with the development:

- Learning to integrate servlets with database - overcome
- Generating webpages through servlets/Java instead of making them in a software like dreamweaver - overcome
- Generating Dynamic web forms using the database entries - overcome
- Designing a large system with multiple functionalities - overcome
- Protecting against SQL injection - overcome
- Protections against URL manipulation - Overcome
- Learning to create sessions and using session variables - overcome
- Developing a CSS for uniformity of the website - not overcome

2.3. Security

With the sensitivity of the data housed in FEMIS, security is of the utmost importance. The front end needs to be protected from vulnerabilities such as sql injection, cross site scripting, malicious file execution, improper error handling, url manipulation.

At this time the system is housed on a Pace University server that maintains the MySQL server all security associated with it. It is important, however, to note some security concerns with MySQL. The user names and passwords of MySQL are housed on a table named mysql.user and therefore it is important that this table only be accessible by an administrative account. The logs of MySQL also need to be in a secured folder that is accessible only to administrative accounts in order to prevent any account information from being exposed to non-administrative users.

3. Crime Scene Procedures

There has been careful consideration for the methods that various investigators have implemented in their crime scene.

Currently the daily procedures are as follows:
1. Photographing [crime scene and evidence]
2. (Possible) sketch [crime scene]
3. Examination of crime scene [every speck is looked over again and again]
4. Analysis of crime scene [possible scenarios]
5. Identification [all items individually]
6. Tagging [all items individually]
7. Sent away for further testing

In order to prevent error and mishap, FEMIS provides field personnel the ability to enter information directly into the system. Since FEMIS is a web based database system, field investigators can enter data into the system with smart phones, wireless internet and satellite communications. Adding barcode printers and scanners in the future to the field personnel deployment kit could greatly improve efficiency. All authorized personnel can continue their investigation in a much more organized fashion. Organized database approaches that will leave little room for error, never the less, will allow the investigator to continue his/her research on a much more definitive level.

![Figure 4: Body Outline](image)

### 4. Collected Evidence

The collected evidence is of the utmost importance and without evidence such as DNA/ Blood, fingerprints, journaling, photos etc it becomes close to impossible for the investigators to solve any such crime. For this reason, all evidence is given careful attention and consideration not be over looked.

Of the entire evidence collected, however, there are several that hold precedence over the rest. The understanding of these evidences will most likely lead you in the direction of the ruffian thereby bringing you closer to bringing them to justice.

All life forms carry a specific set of DNA/ Blood, fingerprints, and hair follicles. It is for this reason that collecting these pieces of evidence is so crucial towards the case. Doing so will allow the investigator to dig deeper and perhaps find the assailant. It also helps play out the stages in which the crime occurred. Was the assailant a known or unknown to the victim, did the victim try to fight back? It may also exonerate someone who might simply be in the wrong place at the wrong time.

#### 4.1. DNA (Deoxyribonucleic Acid)

DNA since its introduction into forensic science has not only revolutionized the way we capture assailant(s) it has also helped us to narrow the margin of error.

Before the use of DNA testing, there were many discrepancies in finding and bringing the assailant to justice. Now that we have the ability to test and compare DNA it is highly probable that the correct assailant is linked to the crime.

Each human person contains 23 pairs (46 in total) of chromosomes. Additionally each person has DNA that is partly taken from each parent. DNA, when broken down, is made up of phosphate groups, sugar groups and four types of nitrogen bases. The genetic coding for the nitrogen bases found in DNA are; adenine (A), guanine (G), cytosine (C), and thymine (T). Nitrogen bases form a ring structure from the bonds of hydrogen between contrasting and complementary strand links.

Ironically enough 99.5% of our DNA is virtually identical from one human being to another. This leaves us with only 0.5 % of every person’s DNA that sets us apart from the rest. It is within this 0.5% that scientist are able to decipher one person from the next.

Never the less, DNA also falls victim to expire due to time [decomposition of the body] or weather [rain, too much sun exposure]. Collecting this information is extremely crucial when it comes to identifying the assailant and must be done in a timely fashion. FEMIS proposes to collect such data, link them all together and store it so that it is readily accessible, no matter the inquiry time. The amount of evidence can also be relevant. For example, remains of September 11th victims were not all usable in 2001 because there was not enough of a sample to extract usable DNA. The victim’s remains were carefully stored for future use. In 2007, the medical examiner’s office reopened the case after the Bode Technology Group developed a new methodology in extracting DNA that permitted for less of a sample to be present, allowing for more victims to positively be identified.
Fingerprints have been a part of our justice system since the 1800’s. Fingerprints are left behind on a surface we touch due to secretions from eccrine glands in the finger tips. Fingerprints do change over time but just like DNA everyone has unique fingerprints. We have only added this as a tool in crime fighting. Although there are up to ten parts of the fingerprint pattern that an investigator looks at, there are only two layers of the fingerprints; the top layer (stratum corneum) and the lower layer (stratum mucosum) that make up these fingerprint patterns.

The ten fingerprint patterns [according to Police Procedure & Investigation. Lee Lofland] are as follows;

- Delta - point of ridge near divergence.
- Divergence - two parallel lines separate.
- Core-center pattern.
- Comparison-matching similarities of ridge patterns.
- Bifurcation - fork dividing point on fingerprint.
- Common - continuous line.
- “T” junction - T forming intersection.
- Dot - tiny ridge resembles a small dot.
- Row of dots - continuous line of two or more dots.
- Trifurcation - dividing point, one line forming three.

4.3. Footprints

In case an individual steps in soil or mud or wet cement their shoe leaves a foot print. If there are multiple foot prints belonging to the same individual measuring the length of each stride can help determine the height of the person. Also the depth of the footprint can give an approximate idea about the weight of an individual. Let us not forget that every shoe model has a distinct sole which also helps linking an individual/suspect to a crime scene. In order to collect the footprint as evidence Ultrical 30 is used as a cast.

4.4. Ballistics

Crime scenes can contain several clues in addition to DNA, fingerprints, ballistics and or firearms which can create a direct link to the criminal. Every gun has a unique pattern that its barrel leaves on the bullet as it travels through it. The size of the bullet helps narrow down to a particular weapon type which can range from a sniper rifle to a handgun. Once the bullet from the crime scene is recovered and the weapon type is identified the department can proceed with trying to track anyone who might posses it with any remote connection to the crime scene. Every gun has a serial number and anyone that has a license to possess a gun must register it with the government. Using the serial number on the gun the owner can be tracked down with the help of this registration. Most criminals are cunning enough to file off the serial numbers on the gun. Without the serial number every gun of a particular type might appear the same, however, the ballistics are still unique. In a situation like this, the ballistics from a weapon found are compared to the bullets and/or casings found at the scene.

In order to perform this analysis the gun is fired into a chamber filled with foam or cotton and a few cardboard separators. The foam/cotton provides resistance and holds the bullet while the cardboard gives an approximate idea of where to look for the bullet otherwise it would be difficult to find.

If the ballistics are a match there are ways of detecting whether a person has used a weapon or not. One way would be for fingerprints. Another way of detection is to test for gun powder residue, which is evident for 48 hours even if the person who fired the gun washes their hands. The gun powder residue can be detected because it is very fine and stays on the individual’s hand.

The trajectory of the bullet is a very important factor in redesigning the crime scene. This feature can determine the distance at which the weapon was fired and perhaps at which angle. The analysis of this information helps determine the relationship of the attacker with respect to the victim. All these are subtle clues that help bring the investigation closer to the offender.

Distinctive grooves are created once the gun is fired. These are shown on the side of the bullet.
4.5. Soil Samples

Since soil is common in all parts of the world one would gather the importance of having a sample.

The consistency in texture and mineral content of soil changes as we move from one place to another. So much so, that unless the soil in your own backyard has been brought in from an external source for a specific purpose, you will notice that some patches will not even sprout a blade of grass which unfortunately nothing can be done about. Collecting soil samples from the crime scene and later possibly finding the same sample on a suspect’s shoes, clothes, or under their fingernails helps place him/her at that location, thus, establishing a link.

4.6. Broken Glass

In the case of a break in or a struggle there is an excellent chance of finding broken glass. Such as soil, broken glass can possess individual characteristics. Even glass made by the same individual or manufacturer can vary in thickness, molecular breakdown, etc. There are chances of finding small pieces of glass embedded in the skin of an individual or even stuck between clothes which might go unnoticed.

4.7. Investigative Journaling

Journaling is an important aspect of the investigation that is often overlooked. This is the part of the investigation where the written word has become very important. What a person said, how they responded, what they wore or even the descriptions of others are all very important. Investigators do their best to gather around the crime scene in order to gather information, but also to talk to those who may have seen something or who might have been attacked or anyone closely related to the victim.

All information is either recorded on a recorder or written down and later used as a frame of reference. This too, may be logged into FEMIS in order to have continuous access. Audio clips may be digitally stored into the system and made available for download or simply to be heard. Also once an audio clip is entered into the system it shall be locked in. No changes will be permitted. This will help maintain the authenticity of the clips preventing anyone from editing them.

4.8. Photos

Photographs are taken of the crime scene, in addition to every piece of evidence and fingerprint that is found. Photographs play an important role in helping the investigators remember the crime scene and keeping a memory of the fingerprint should it become distorted. Often times when fingerprints are taken, investigators usually take a picture of the discovered fingerprint in order to match up the print once it is lifted from the crime scene.

Additionally photos can help to bring the crime scene to life for the investigator and perhaps trigger a memory or a revelation of some sort. FEMIS can help to keep an accurate track of photos and make them readily available in order to dig deeper within the case. FEMIS monitors who took the photos, the equipment used where the photo was taken from and a description of the photo. Since digital photo editing is rather common these days, the pictures need to either be on Polaroid or once put into the system secured, just like the audio clips.

5. Conclusions

It is the intent of FEMIS to provide a platform that will offer law enforcement, laboratories and district attorneys the opportunity to keep a watch over everything that is brought in as evidence. Any updates made to an investigation will be available to them online to check through FEMIS and any given time and location. FEMIS promotes inter as well as intra agency communication which can sometimes lead to delays. With the help of FEMIS they will unquestionably bring to practice a vice in which various pieces of the puzzle join in order to fight crime.

Today’s technology has put us far ahead of the rest, in terms of rightfully identifying villains and such. In order to take this a bit further, however, FEMIS will allow others to quickly access various information on any one case. Collecting information such as DNA, blood and or journaling are at the very core of these cases and can perhaps determine who the correct assailant(s) are.

The gathering of such information has proven to be an important part of the investigation. Many of these materials are time sensitive and in need of quick attention. Information such as DNA, blood and the like are
subjected to the sensitivities of weather. Over time, the needed information the attacker has [unknowingly] left behind will start to fade, diminish or perhaps become eaten by creatures of the earth.

FEMIS proposes to remedy this situation by rallying this information in such a way that it will help to bring justice to many victims in a matter of days versus weeks, months or even years.

6. Future Work

Although some of the security issues involved with the system have been addressed, there are still a few others that need to be resolved. One in particular is authentication of the user accounts.

It is recommended that the next team consider adding algorithm to compare pixilation of photos for accuracy. This can be addressed further by discussions with Dr. Cha and Dr. Athanasopoulos. Some other modules that we recommend integrating into the system is the ability to view 3D pictures and also a mapping system.

It is recommended that the next team also meet with the local law enforcement agencies and District Attorney’s offices to further discuss their needs of the system. In order for FEMIS to gain acceptance for agencies that are not already accustomed to using computers on a regular basis takes careful planning. The team of Fall 2009 has had the opportunity to meet with law enforcement officers over the phone and the lab in person.

A great deal of funds have gone into the development of the Forensic Laboratory systems that are run at the county level and each lab may not currently have the same system in place. Further research need to be conducted to determine whether it would be beneficial to add module linking into the existing systems or an effort to completely overhaul the systems in place would prove pertinent.

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7. References

[4] Discovery Channel
[5] FBI Iospecs (Does anyone remember specifically what this is???)