MAAI: MEDIA ANALYTICS FOR ACTIONABLE INTELLIGENCE

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ABSTRACT

Government agencies, corporations, and police departments are plagued by information overload. The inability of fully analyze fragments of data scattered across the organizations reduces productivity, and more and more of these fragments are being gathered every day thanks to tools like the internet and digital audio/video recorders. However, since much of this information is stored in computer systems and networks, it is possible to develop tools that will automatically analyze, assemble and associate the fragments so that precious human resources can focus on the analysis and interpretation of just those fragments that may contain valuable insight. Media Analytics for Actionable Intelligence (MAAI) is a combination of automatic, semi-automatic and manual tools which provide three basic levels of analysis: automatic services, manual feedback, and higher level mining (e.g. timeline, social network, hypothesis generation) which allow investigators/analysts to act more efficiently and accurately.

***Index Terms*—** Multimedia Analytics, Law Inforcement, Timeline, Social Networks

1. INTRODUCTION

With increasing challenges being placed upon police departments due to higher crime rates, understaffing and reduced budgets, police need to find new tools to supplement traditional investigative techniques. These challenges are compounded by the fact that criminals are becoming more advanced, using technology to help commit crimes and build intricate crime networks which facilitate the sharing and disseminating information, issues that make it increasingly challenging for law enforcement professionals to stay ahead of those committing crimes.

In a typical criminal investigation, the officers in charge of solving the crime need to gather data from a multitude of information sources comprising a variety of modalities (images, audio statements, videos, lab reports, . . .). Some of the challenges faced by police officers investigating such crimes span the gamut from gathering, processing, analyzing and disseminating the results of their analysis. Traditional information processing tools such as relational databases and enterprise content management systems fill certain gaps in the gathering of information, and in limited cases, dissemination of the analysis. However, there are very few tools, if any, that are available to crime investigators that address the multimedia aspect of the information pertaining to crimes and facilitate processing and analysis of these sources. Moreover, the ever increasing volumes of data gathered must be addressed.

Lack of such tools and processes has hampered several investigations in the recent past leading to a call for Criminal Case Management tools and processes. See for instance the notorious Bernardo case from Ontario, Canada[1] which led a national campaign for Major Case Management tools and techniques in Canada.

IBM Research and Cape Breton University recently collaborated on a first-of-a-kind project where they teamed with a regional Canadian Police force to develop a combination of automatic, semi-automatic, and manual tools which help in analyzing large volumes of data, building insights from the analysis, and then facilitating dissemination of the results for the purposes of criminal prosecution. In this paper we describe the capabilities that this toolset offers to an investigating officer for Information Management and Processing.

2. A NEW APPROACH: MEDIA ANALYTICS

The broad goal of Media Analytics for Actionable Intelligence (MAAI) is to increase the productivity of an investigator. In a typical usage scenario content is analyzed initially with a set of automatic analysis, for example speech recognition, speaker recognition, language identification, named entity detection, etc. The general infrastructure used is based on UIMA (Unstructured Information Management Architecture) [2], whose components facilitate flexible information extraction from "unstructured data." [1]. Automation allows much larger volumes of data to be ingested and dealt with that might otherwise be ignored. This process generates a wealth of metadata that can be used in further analysis. However, this metadata may contain some or many errors depending on the maturity of the automated tools used.

[1] http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=M1ARTM0010959

This issue is addressed in the second level of analysis: the component of MAAI that allows manual analysis of data and editing of metadata. Manual editing complements the automatic analysis and improves the accuracy of the metadata. Specifically, a ”human in the loop” UIMA annotator was developed to provide this capability. More generally, this stage allows the analyst to add new annotations and metadata based on prior information that may be available, for example from a previous investigation.

In the third stage of analysis, the relationships or associations among elements in the database are highlighted. A social network component automatically finds associations between the elements in the data. These are combined with manually added associations and visualized in a graph. Timeline construction and visualization gives another view of the data that is very important because it describes how the elements of the data are temporally related to one another. The timeline visualization tool permits zooming from years all the way down to seconds and displays the relevant data for the timescale. The resolution of detail could be based for example on the significance of the data as determined by the social network.

Finally, inferences made based on the social network and timeline are used to create a disclosure document and could further be used to generate hypotheses which are fed back into the system to alter the analysis, for example by focusing on certain elements of the data or certain types of analysis.

3. MAAI CRITICAL SYSTEM COMPONENTS

After analyzing the possible needs of police departments we categorize the work performed during a criminal investigation into four stages: 1)gather the information, 2) turn raw data into usable information assembled and ready for analysis, 3) perform assessment and analysis based on the information assembled, and 4) present the conclusions inferred from the analysis process to the investigators and to the prosecution as a disclosure document.

The three levels of analysis in MAAI correspond to subsets of these four tasks. The various levels of analysis are accessed through the toolkit interface, the Detective Workbench , which is comprised of some pre-existing applications together with newly developed components.

Access to the toolkit is controlled by a biometric verification procedure [4]. Mechanisms can be provided to grant varying level of access to parts of the database with specific security requirements.

Traditionally, the data is collected by a person, which we will refer to as the ”File Case Manager” (FCM), who is in charge of collecting, storing, and analyzing the data. In an investigation the data not only comes from different sources, but it could be gathered and archived by different members of the investigation team. In our application multiple investigators can aid the FCM by using the data manager component to directly enter data collected during their investigation.

The Data Manager’s main functionalities are creating, querying and accessing the entities in the database. An entity is defined as a person or a resource, which in turn comprises of every possible source of data collected or produced during the investigation. A person is identified as any physical or legal entity part of the investigation.

3.1. Automated Analysis

After gathering all of the evidence from a crime scene, collecting statements from people of interest and from each of the member of the investigative team, and researching additional information pertinent to the case, the ”FCM” has to transform all of the ”unstructured” data into ”structured” data that can be used for knowledge-discovery.

A partial description of the possible challenges that he faces at this stage are the following: 1)prepare descriptive text notes on the photos and documents and add them to the case file, 2)pull key facts from the individual crime scene reports and add them to the case file, 3)create summaries or cut/paste internet information into the case file, 4)review video images to identify people using other police files or human experts, and 5)transcribe audio tapes, translate if necessary and add transcripts to the case file.

Many of these tasks can be handled in an automatic or semi-automatic way. The bulk of the automated analysis is carried out through the use of UIMA[2] . Most if not all of these tasks have been studied for years and tools to perform them in automatic fashion are available.

Most of the engines used in the application are used to annotate the available data. Moving ”unstructured” to ”structured”. For example an STT (Speech To Text) annotator can automatically transcribe audio collected during an interview, speaker and language identificators annotators can analyze large volume of audio and find section of interest. A Named Entities Annotator [3] is used to find and annotate ”Person”, ”Places” and ”Times” entities in the collected statements or a selection of them depending on the query value specified when running the engine.

Associations can automatically been inferred from the metadata that is present within the system, whether it was generated by the analysis engines or entered manually. Moreover, the associations can connect anything in the database, including the data artifacts as well the meta-data.

3.2. Manual refinement and analysis

Even though most of the tools do not produce perfect results, it doesn’t represent a major bottleneck in our application since given the nature of the task a human in the loop is not only necessary but mandatory. Criminal investigation, insurance

[2]http://incubator.apache.org/uima/

[3]IBM Statistical Text Analytics Group’s KDD-model Annotator

or medical fraud are domains so sensitive that the data produced has to be reviewed by a knowledgeable person before any judgment or assessments can be made.

It is known that the automated annotators have varying levels of accuracy, for example Named Entities Annotators and are not 100% accurate [3]. However such accuracy is a fundamental requirement in the MAAI task. To improve the quality of the results, the automatically generated metadata (for example the transcripts and the named entity tags, etc.) can be viewed and edited through the ”ViaScribe”1 tool.

IBM ViaScribe is a platform that facilitates automated or semi-automated transcription, annotation, captioning, and has the following features: 1)live transcription, 2)offline user interface for error correction and annotation, 3) automatic synchronization of audio, transcription, annotation, and visual information (slides or videos) into XML, HTML and SMIL multimedia streams.

In the context of MAAI, ”IBM ViaScribe” was extended to become part of the UIMA analysis pipeline. Added to the tool was the ability to process CAS (Common Analysis Structure) objects, which carry the data and the associated metadata through the UIMA Analysis pipeline. This gives the users the ability to edit or add to the metadata created by other UIMA annotators, tors, such as the Named Entity Annotator or the STT Annotator.

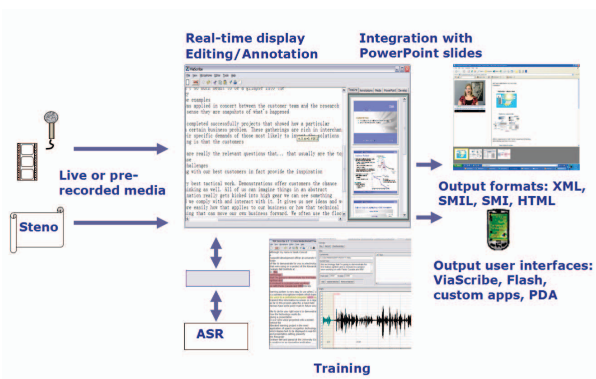

Fig. 1. Viascribe

3.3. Higher Level Mining

3.3.1. Social Network Component

The output of the UIMA annotators is hierarchically structured according to a type system. Metadata is produced in the form of annotations. Fields within the annotations are matched, or partially matched, in order to produce associations. Additionally, the relationship of annotations in a document stored in a CAS are also used to infer associations. For example, if a statement is being analyzed and it is found that two individuals are mentioned in relation to a specific event, these two individuals would be connected with an association. They could also be connected to the event and/or the person giving the statement. If an individual giving a statement mentions a specific item, like a car, then that person would be associated to the particular car.

The accuracy of the connections is important because the aggregate set is analyzed to determine the significance that should be attached to elements in the database. For example, conditions on link density and strength, and element connectivity can all be used. However, if too many connections are hypothesized, there will be noise in the link data. This should be avoided because the significance is subsequently used for case based inference and as a means to guide re-analysis of the data. In the process of investigating a case, a graph is built up as the analysis proceeds. The social network visualization component[4] gives a view of the graph that is built up in a number of different formats. Looking at the data from multiple perspectives can give a better understanding of the evidence. Moreover, these graphs could be stored in a repository for future reference. For example, if at some later time, or contemporaneously, but in a different location, it is noticed that a similar graph structure is being built to one that already exists in the repository, it could be inferred that the same or similar case is being worked on. If multiple organizations are investigating the same case, they could pool their resources to do a better analysis.

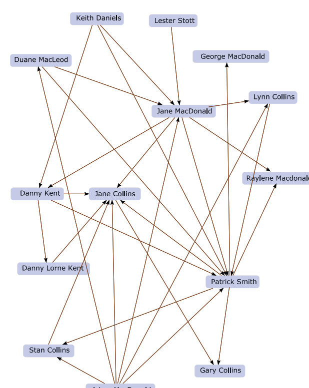

Fig. 2. MAAI Workbench: SocialNetwork Graph

3.3.2. Timeline Visualization

Another complementary view of the data is given by the Timeline Component, which allows the FCM to answer questions like: What was happening in the hours before, during and after a crime? or arrange the available information by location to answer: What was happening at or near each crime

[4]The Prefuse toolkit [http://prefuse.org] was used in rendering the graphs

scene?, or arrange the available information by person to answer: Where were "the persons of interest" when the crime was committed? In Figure 3, a screen shot of the timeline implementation is shown. The entities "Person" and "Location" are displayed over an interval of time, which can be predefined using the "Begin Date" and "End Date" options. It is possible to shift the time interval using the upper wheel or to zoom in and out into the interval time. The finest level of zooming is milliseconds.

Fig. 3. MAAI Workbench: Timeline Visualizer

The need to review complex time-aligned data is pressing in many real-life analytical systems. For example, cause-effect relationships can be physically time-aligned. An event in the future can be the result of previous actions. A visually represented time alignment can reveal or help to reveal such connections.

The way the time events are displayed is task-dependent. In one case, the investigator may need to see all details about a certain event. In another, the details are may not be as important as a specific pattern of event across the time line (i.e. an event of type A always happens after an event of type B). The variety of real-life situations will be explored as further research.

3.4. Disclosure Document

The findings are summarized into an an HTML file, called *"DISCLOSURE"*, with links to each piece of data collected and produced, and a list of each "Person" in the database as well as each "Association" discovered.

4. DISCUSSION AND CONCLUSIONS

It is becoming evident that technology is having a significant impact on police investigations as the tools can help productivity, increase time available in the field, enable the seamless sharing of information between officers while providing the potential to decrease the time required to solve a case. The MAAI toolset, a data mining and content management solution geared toward investigators and analysts, was extensively tested at Cape Breton University with significant input from the Cape Breton Regional Police Force. All facets of the system were analyzed both individually and in combination. Though the names and specific details have been changed, the figures in the paper depict the results from the analysis of an actual investigation. The MAAI system was able to identify the key individuals and events in the case. Significantly, the consensus opinion reinforced the motivation for MAAI, as an embodiment of the future of investigative workflows and the next step toward less administrative policing tasks. Additionally, as crime becomes a borderless problem, computerized technologies allow police to more readily share information across geographic boundaries.

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