

Digital Forensics Experimentation: Analysis and Recommendations

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ABSTRACT: Digital forensics (DF) is becoming one of the most prestigious research areas in computer science due to its inherent nature of providing a means to acquire, examine, analyze, and report evidence to be used in legal processes. To successfully perform it, novel techniques, approaches, and tools have been proposed, experimented on, and evaluated by researchers. However, the experimentation process is not a trivial task in this area as substantial evidence is not accepted in court. Therefore, the experimentation process has to be improved in DF, especially its documentation and data sharing to enable its reproducibility. The objective of this paper is to characterize the state-of-the-art research on DF experiments. We conducted a Systematic Mapping Study (SMS), analyzing 107 primary studies reporting DF experiments. We demonstrate that DF experimentation somehow fails at documenting the most essential elements of an experiment, such as hypothesis, variables, design, instrumentation, validity evaluation, setup, training, datasets and benchmarks, statistical techniques (descriptive, hypothesis, and effect-size test), limitations, and data sharing. In this work, we also propose a set of recommendations to improve experimentation in DF, especially regarding its replication and reproducibility. DF experimentation should evolve if the community intends to provide reliable and reproducible studies. By embracing this, both academician and practitioners might benefit from such experiments and evidence.

KEYWORDS: Evidence, experiment, recommendations, replication.

INTRODUCTION

Experimentation plays a central role in science in general. However, such a role is unclear in computer science [26]. Several different areas of computer science have applied experimentation in the last decades to provide evidence on a certain cause-effect previously established theory [29]. Digital forensics (DF) [14,24] is one of these areas. As DF has grown in the last decades due to the outstanding advance of information technology, it has provided interesting solutions for several different subareas, such as cloud forensics, network forensics, and mobile device forensics. Such solutions have contributed to promoting reliable evidence to be used in legal processes. These solutions go from low-level abstractions, such as volatile memory analysis and network package attack monitoring, to high-level ones, such as cloud computing solutions. DF research plays a central role in the evolution of science, especially criminal sciences.

However, it is widely noted that DF solutions are not empirically evaluated as much as in classical sciences—e.g., medicine. Formal experimentation with DF solutions has been given little attention for reasons such as difficulty establishing experimental designs, time spent, and costs involved to set up and perform such experiments [6]. Besides, such performed experiments are generally poorly reported—hence, the essential information to allow their repetition, replication, or reproduction is missing. Therefore, the reliability and potentiality of science evolution are jeopardized [9,28].

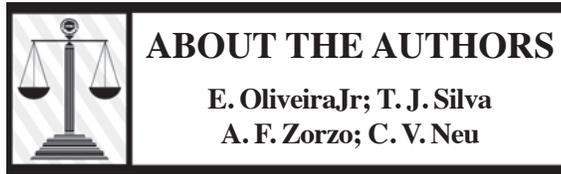
Several authors have discussed different problems regarding DF experimentation. Marshall and Paige [18],

for example, discussed the lack of clear requirements for developing new DF methods according to ISO 17025:2017^a capabilities, especially rigorous scientific method and verification, such as experimentation, and repeatability to provide reliable evidence to be used in court.

Furthermore, Casey [6] previously discussed the challenges of experimental design in DF. According to Casey, “designing good experiments is hardly a trivial undertaking, and has been the focus of brilliant minds at least since the scientific revolution ... experiments in digital forensics pose novel challenges”. Such challenges vary from the accuracy of making observations and testing hypotheses from the perspective of the studied environment, the complex influences as the setup of the experiment and the experimental objects used, to the lack of reproducibility to allow someone to run the same experiment multiple times and to verify its results. Casey also discussed experiments’ completeness of reporting results and setups. The correct interpretation of findings is another issue to be considered since a degree of scientific skill is required to accurately interpret results and to provide acceptable evidence. Per another viewpoint, Horsman [11,12] discussed the need for admissible evidence in DF. Thus, he claimed that the results of any DF investigation should be reliable, based on scientific procedures and interpretation, and transformed into facts. To do so, he proposed a Framework for Reliable Experimental Design (FRED) [12] applied to the three major DF process phases: acquisition, examination/analysis, and reporting.

^a<https://www.iso.org/standard/66912.html>

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