

CMU|Portugal

Undergraduate Internship Program – Summer 2015

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This report describes briefly the work and activities that I have done during my 9 weeks internship at Carnegie Mellon University, hosted by Prof. André Platzer and Ph.D. student João Martins, from the Computer Science Department.

The first 2 weeks were essentially to review my studies in Cyber-Physical Systems (CPS), finishing some exercises from Prof. Platzer's Foundations of Cyber-Physical Systems course, and to be familiar with Epistemic Logic, reading a few chapters from the book *Dynamic Epistemic Logic*, written by Hans van Ditmarsch, Wiebe van der Hoek and Barteld Kooi. João Martins gave me a great guidance along these first steps.

After this, I started to consider the Air France Flight 447 accident, as a set of case studies, and tried to define basic models, each representing an associated epistemic problem (a case study) that really influenced this accident. Proofs were done for each of the models, finding and assuming few epistemic rules on CPS. Indeed, CPS with Epistemic Logic was a recent research, with not many rules proved to be *sound* in the system, so far. It is required that all rules are *sound* because if they are not then we can "prove validity" of invalid formulas with such rules.

Meanwhile João and I proved that it is possible to prove formulas within epistemic operators by arithmetic, which is a very important property for the system. We already know how to reason about pure arithmetic, but we lose the ability to do so when we add knowledge. Finding a way to do arithmetic inside knowledge is a crucial step in reducing "epistemic arithmetic" to either pure arithmetic or pure epistemic logic, both of which we know how to handle.

I tried to improve and put together the developed basic models into a single more complex model, also including some physical constraints, and then tried to demonstrate its validity, using the previous proofs to make this proof easier.

However, I found out that I definitely needed new proof rules to continue my proofs and that one rule (Learning test rule) that we believed to be *sound* was not actually *sound*. This made us to be more careful about certain changes of epistemic states during the program execution and not compare them directly to changes of non-epistemic states. With Prof. Platzer's help, we got the missing rules and corrected the rule that was not *sound*. After that, with an important contribution from João, we tried to improve this new Learning test rule and to prove that it was *sound*. We also proved the *soundness* of another new proof rule that was useful and very interesting because it means that if we have some knowledge about specific properties then these properties surely hold in the real world.

The last part of my work was to finish the aforementioned proof for the joined case studies model.

Over free time I could attend a couple of events at the Carnegie Museum of Natural History and the Phipps Conservatory, for instance, and also had nice walks in this beautiful city.

Having this opportunity to work in a CMU internship I undoubtedly grew up in many aspects. The most relevant lesson, that I gain to observe colleagues from CMU and people from Pittsburgh also, was notice that I should be more active every day, doing more profitable work and leaving things with less importance, almost unnecessary. I am really thankful to CMU Portugal Program, my host at CMU, Prof. André Platzer, and my sponsor from FCUP, Prof. Ana Paula Tomás, to believe in me and help me before, during and after all the process. I want to make a special acknowledgment to João Martins, a very open colleague that showed a high consideration for my work. He is also a remarkably careful and talented person and gave me an invaluable support over my internship.