CuneiForce: Involving the Crowd in the Annotation of Unread Mesopotamian Cuneiform Tablets Through a Gamified Design

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Abstract. We present the concept and early design of a crowd computing system that aims at involving people in the annotation of unread cuneiform tablets, in an attempt to (i) increase public awareness about the history of Ancient Mesopotamia and (ii) to supplement the shrinking force of experts in the subject with the contributions of interested individuals, who are instructed in reading from the simplest inscriptions towards more complex ones in a gamified strategy.

Keywords: Crowd computing · Serious games · Cuneiform writing · Digital Humanities.

1 Introduction

Cuneiform was one of the earliest systems of writing, emerging in Sumer (modern-day southern Iraq) in the middle of 3rd millennium BC and used until the 1st century AD for the writing of the various languages used by the oldest major civilizations in the region of Mesopotamia and beyond, namely Sumerian, Akkadian, Assyrian, Babylonian, Elamite, Hittite, Urartian, Ugaritic and Achaemenid.

Mesopotamia is generally dubbed "*the first place where civilized societies truly began to take shape*". Therefore, the study of the History of the region plays a key role in understanding the consolidation of the earliest developments of agriculture, cities, laws, long distance trade, ... as well as the rise and fall of the first empires, and the many advances that sprung therefrom to influence posterior civilizations.

Much of what is known about Ancient Mesopotamia comes from archaeological evidence. Among the remains, it is estimated that between 0.5 and 2 million cuneiform tablets have been excavated in modern times, of which only 30 000–100 000 have been read or published [24]. Therefore, there's a wealth of knowledge awaiting to be deciphered and put into context. Unfortunately, Humanities enrolment has dropped dramatically since the early 2000s, as parents and educators around the world have encouraged students to pursue degrees in science, technology, engineering and mathematics, where employment opportunities are seemingly endless [23]. Having fewer (and older) experts in the area of Ancient Mesopotamia History entails a clear risk that most of that knowledge will remain in limbo [13].

Paradoxically enough, we believe technology can play a role in preventing this from happening. During the last two decades, the Digital Humanities have seen many successful applications of *crowdsourcing* models, in many cases pursuing the transcription of handwritten manuscripts from medieval and modern times [22]. Often, these applications fit the more specific definition of *crowd computing*, which systematises the intertwining of human and artificial intelligence, aiming to solve tasks that are hard for people or computers to do alone [11]. The key principles include the following:

- *Automation:* machines do non-creative and repetitive work, providing a cascade of knowledge for humans to evaluate.
- *Microtasking:* work is broken into small tasks that are easier to complete by humans, chosen specifically on the grounds of their expertise.
- *Mixed crowd:* a greater volume of work, and of greater value, can be completed when specialists and open communities work together.

In this paper, we present the concept and early design of a crowd computing system that aims at involving people in the reading and interpretation of cuneiform tablets, by means of a game that challenges them from the simplest known inscriptions, progressively, towards more complex and unknown ones.

2 Some quick facts about cuneiform

The first writing began as a system of pictograms in the late 4th millennium BC. In the 3rd millennium BC, the pictorial representations turned to abstract shapes as the number of characters in common use became smaller. The system thus evolved into a combination of signs that, as noted above, was used for the writing of different languages over the centuries. The HZL lust of signs used in Hittite cuneiform, for example, contains a total of 375 signs, many with a few variants [19].

Because of its versatility, transliteration from cuneiform requires deciding, for almost each sign, which of its several possible meanings is intended in the original document. For example, the Sumerian sign DINGIR (𒀭) in an Akkadian text may represent the syllable "*an*" (as in the word "*antallum*" = eclipse), may be

part of a phrase (reading "*ilum*") and it may translate as "*god*". This is precisely one of the challenges that we want people to address in the proposed game.

Finally, it is worth noting that cuneiform was used to record many different types of documents: laws, maps, medical manuals, religious stories and beliefs, business records, personal letters, etc. Cuneiform tablets, therefore, can convey quite a complete view of the society of their times, owing to the fact that literacy was not reserved for the elite; rather, it was common for average citizens [4]. This wide scope gives great flexibility to design the learning curve of the game, with different itineraries that may even be adapted to each user's interests and preferences.

3 The CuneiForce system: Early design

We have started to design CuneiForce as a crowd computing system that will bring together innovative solutions in computer vision, automated reasoning, knowledge modelling and crowdsourcing (see Fig. 1). At the core of it, we aim to create (and ensure others' contributions to) a semantic knowledge base linked to the existing archives of digitized tablets (e.g. the Cornell University's Cuneiform Library[5] or the Cuneiform Digital Library Initiative[6]).

The knowledge base will rely on an ontological model created according to reference metadata standards, like CIDOC-CRM [6], with proper additions to represent arguments (e.g. CRMinf, an extension of CIDOC-CRM itself) and uncertain or inconsistent information [3,12]. Additionally, we aim to develop a neural network model like that of Word2vec [15], but for Ancient Mesopotamian languages rather than English. Both models will help to explicitly capture incomplete or inconsistent knowledge, different levels of certainty, different interpretations and arguments.

The computer vision solutions will be based on recent advances in deep learning and convolutional neural networks [20] —also on the achievements of the Transkribus system[7] with manuscripts in Latin scripts— to recognise individual wedges and to make informed guesses about their aggregations. Multiple instance learning will be combined with structured prediction and weakly supervised learning to allow automatic segmentation of the images. The automated reasoning processes will work on top of the knowledge bases to establish associations and correlations, aiming to provide humans with hypotheses about how to complete missing information or manage contradictions (if necessary). We plan to integrate mechanisms from several areas of artificial intelligence and logic:

– Qualitative, rule-based approaches for defeasible reasoning [16,18], which allow making conclusions that could be invalidated in the light of new information.

[5] http://cuneiform.library.cornell.edu/
[6] https://cdli.ucla.edu/
[7] https://transkribus.eu/

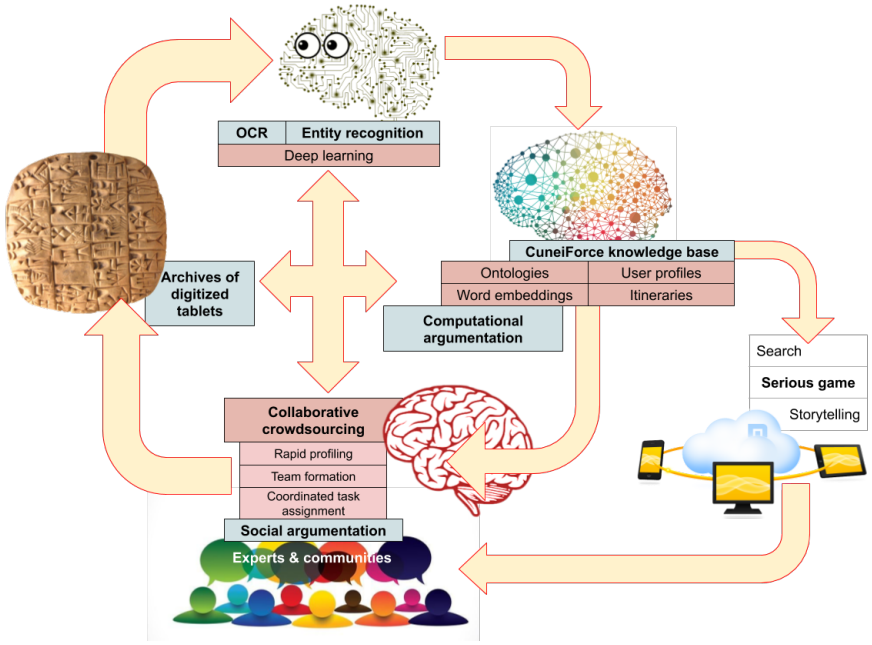

Fig. 1. Overall design of the CuneiForce system.

- Quantitative, fuzzy approaches for probabilistic/statistical reasoning [5,21] needed to handle the guesses coming from the computer vision systems and the wisdom gathered from humans through social argumentation (user-generated arguments and votes on arguments).
- Abductive reasoning [10], aiming to discover new rules from incomplete sets of observations.
- Approaches based on many-valued logic for paraconsistent reasoning [9,8], needed to avoid trivialisation (any conclusion follows) from contradictory bits.

On these grounds, computational argumentation [17,7] will provide tools for modelling and reasoning about the support for/against any conclusions.

Finally, the collaborative crowdsourcing solutions will combine virtual team formation and coordination with *macrotasks* and complex problems in the shape of personalized learning paths. Since we are targeting the wider public, personalization is crucial to promote long-standing involvement, preventing dropouts due to improper learning curves, uninteresting topics, etc. Task assignments optimization will be inspired by the work presented in [2]. This approach goes beyond traditional microtasking, which typically views participating users as a fully replaceable, low-skilled and anonymous mass. Personality matching [1,14] will be used to construct teams that are highly motivated to collaborate and work efficiently together.

4 Conclusions and roadmap

There is a lot of Ancient Mesopotamia History waiting to be read and integrated with our current knowledge. In an era of declining vocations in Humanities, we believe it is possible to gather knowledge from interested people by means of properly-designed serious games. Despite its unfamiliar appearance and the fact that it was used for the writing of languages that disappeared long ago, our experience delivering introductory courses shows that cuneiform script is attractive and accessible enough to expect a level of engagement comparable to crowdsourcing projects that dealt with medieval and modern manuscripts in the recent past. Furthermore, there is abundant material to train AI modules to aid in tablet classification and preparation tasks, plus plenty of online resources available to ensure that users will never be left wondering. Therefore, while the idea does not come without significant research and development challenges, we believe feasibility will not be an issue.

Our plan is to implement and validate the CuneiForce system within the next three years. The present year 2019 is devoted to designing the complete learning itineraries from selected sets of read tablets, and ensuring access to convenient online resources. Year 2020 will focus on the AI in charge of image processing and computational argumentation. Lastly, 2021 will primarily look at the implementation of web and mobile versions of all the user interfaces; it is also scheduled to be the year for validation experiments, not only with the open community on the Internet, but also in the context of collaborating primary/secondary education institutions.

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References

1. Antoniou, A.: Compatibility of small team personalities in computer-based tasks. Challenges **10**(1), 29 (2019)
2. Basu Roy, S., Lykourentzou, I., Thirumuruganathan, S., Amer-Yahia, S., Das, G.: Task assignment optimization in knowledge-intensive crowdsourcing. The VLDB Journal **24**(4), 467–491 (2015)
3. Ceravolo, P., Damiani, E., Leida, M.: Which role for an ontology of uncertainty? In: Proceedings of the 4th International Conference on Uncertainty Reasoning for the Semantic Web (URSW). pp. 132–136. Aachen, Germany (2008)
4. Charpin, D.: Lire et écrire en Mésopotamie: une affaire de spécialistes? In: Comptes rendus de l'Académie des Inscriptions et Belles Lettres. pp. 481–501 (2004)

5. Coletti, G., Scozzafava, R.: Conditional probability, fuzzy sets, and possibility: A unifying view. Fuzzy Sets and Systems **144**(1), 227–249 (2004)
6. Doerr, M.: The CIDOC Conceptual Reference Module: An ontological approach to semantic interoperability of metadata. AI Magazine **24**(3) (2003)
7. Gorogiannis, N., Hunter, A.: Instantiating abstract argumentation with classical logic arguments: Postulates and properties. Artificial Intelligence **175**(9-10), 1479–1497 (2011)
8. Grant, J., Hunter, A.: Analysing inconsistent first-order knowledge bases. Artificial Intelligence **172**(8-9), 1064–1093 (2008)
9. Hunter, A., Konieczny, S.: Approaches to measuring inconsistent information. Lecture Notes in Computer Science **3300**, 191–236 (2004)
10. Janíček, M.: Abductive reasoning for continual dialogue understanding. Lecture Notes in Computer Science **7415**, 16–31 (2012)
11. Kelley, B.: Announcing the crowd computing revolution. bradenkelley.com/2014/03/ (2014)
12. Lembo, D., Lenzerini, M., Rosati, R., Ruzzi, M., Savo, D.: Inconsistency-tolerant semantics for description logics. Lecture Notes in Computer Science **6333**, 103–117 (2010)
13. Long, K.: As STEM majors soar at UW, interest in Humanities shrinks — a potentially costly loss. The Seattle Times (Jan 2019)
14. Lykourentzou, I., Antoniou, A., Naudet, Y., Dow, S.: Personality matters: Balancing for personality types leads to better outcomes for crowd teams. In: Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW). pp. 260–273. San Francisco, California, USA (2016)
15. Mikolov, T., Chen, K., Corrado, G., Dean, J.: Efficient estimation of word representations in vector space. CoRR **abs/1301.3781** (2013), http://arxiv.org/abs/1301.3781
16. Modgil, S.: Reasoning about preferences in argumentation frameworks. Artificial Intelligence **173**(9-10), 901–934 (2009)
17. Moguillansky, M., Wassermann, R., Falappa, M.: An argumentation machinery to reason over inconsistent ontologies. Lecture Notes in Computer Science **6433**, 100–109 (2010)
18. Prakken, H.: An abstract framework for argumentation with structured arguments. Argument and Computation **1**(2), 93–124 (2010)
19. Rüster, C., Neu, E.: Hethitisches Zeichenlexikon. Wiesbaden (1989)
20. Schmidhuber, J.: Deep learning in neural networks: An overview. Neural Networks **61**, 85–117 (2015)
21. Stoilos, G., Simou, N., Stamou, G., Kollias, S.: An abstract framework for argumentation with structured arguments. IEEE Intelligent Systems **21**(5), 84–87 (2006)
22. Terras, M.: A New Companion to Digital Humanities, chap. Crowdsourcing in the Digital Humanities. Wiley-Blackwell (2016)
23. Tworek, H.: The real reason the Humanities are 'in crisis'. The Atlantic (Dec 2003)
24. Watkins, L., Snyder, D.: The Digital Hammurabi project. http://www.jhu.edu/digitalhammurabi/ (2003)