LEDGER
ledgerjournal.org

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171

An Overview of Blockchain Integration with Robotics and Artificial Intelligence: Open Review

Authors: Vasco Lopes, [†] Luís A. Alexandre[‡]

Reviewers: Reviewer A, Reviewer B, Reviewer C

Abstract. The final version of the paper "An Overview of Blockchain Integration with Robotics and Artificial Intelligence" can be found in Ledger Vol. 4, S1 (2019) 1-6, DOI 10.5915/LEDGER.2019.171. There were three reviewers involved in the review process, none of whom have requested to waive their anonymity at present, and are thus listed as A, B, and C. After initial review by Reviewers A, B, and C, (1A) it was determined that the submission required revisions. The authors responded to their feedback and revised the manuscript (1B). The changes were accepted, thus completing the peer-review process. Authors' responses are bulleted for clarity.

1A. Review

Reviewer A:

This paper presents a broad survey of applications of blockchain technology in Robotics, AI, cyberphysical systems, and more. The authors conclude the paper by briefly discuss how blockchain could be applied to robotics and AI.

This paper is not written as a scientific contribution. The language is colloquial, the structure is not adequate, and the largest portion of the paper (sections 2.2 and 2.3, over 6 pages) are completely out of topic with respect to what they should discuss in a symposium for robotics. The paper is also well beyond the mandated limit of 6 pages, being 15-pages long.

Another major issue of this paper is that it surveys existing work acritically. From reading this paper, it is unclear what might be the hurdles to introduce blockchain into robotics, how

[†] V. Lopes (vasco.lopes@ubi.com) is a Researcher in the Departamento de Informática at the Universidade da Beira Interior and Instituto de Telecomunicações in Covilhã, Portugal.

[‡] L. A. Alexandre (luis.alexandre@ubi.pt) is a Full Professor in the Departamento de Informática at the Universidade da Beira Interior and Instituto de Telecomunicações in Covilhã, Portugal.

robotics is a different domain from the current Bitcoin network, and what are inherent technological limitations blockchain has today that must be overcome. Instead, the paper reads like a sort of advertisement piece for blockchain as a generalist technology.

Reviewer B:

This work presents an overview of the current state of blockchain technology in the robotics/AI field. This work is indeed relevant to the Blockchain/Robotics community as well as for the audience of this symposium. However, several points have to be improved in order to reach acceptable quality. In the following lines, I will propose several recommendations and changes:

- Your language is very colloquial and full of subjective and personal judgements. For instance, page 11 “Although this will certainly be a fact in the near future, ...” You should only make judgements/statements based on the references you have (since you are writing a review/overview). Please refer to other review papers and get inspiration in order to use the same type of objective language.
- The paper introduces 3 different sections where the state of the art is evaluated. You should also provide an overview of the limitations and future improvements that each one of these fields have/need.
- Page 5, second paragraph - As far as I know stock exchange data is public. You should clarify the following statement: “only a few data scientists have access to the raw data”
- Page 12, discussion – “Blockchain has the power to store huge amounts of data ...” This is a very questionable statement. Mainstream implementations of blockchain (bitcoin, ethereum, *etc*.) have a significant problem with bloat and therefore it is commonly understood that data should be stored off-chain. Please clarify your statements about this issue.
- Page 13, discussion, first paragraph - You should mention the possibility/impossibility of reaching a blockchain system that can obtain real-time capabilities. This is an important feature for current and future robotic systems. Please refer to this when you make a statement about the synergy of these two fields.

Reviewer C:

This paper overview advances in blockchain technologies and focuses on their application in AI and robotics. The paper is well written and the main ideas communicated, given the space limit. I am in favor of accepting this paper but would like that the authors work on improving some aspects of the papers before it can be accepted.
* robotics part: the authors focus on a few cases of robot uses. It would be better to have a clearer segmentation of robotics domains (based on the type of industries where they are deployed), *e.g.*, manufactories, automotive industry, social robots, etc. This can be done by shortening the description of the referenced papers and doing a more focused grouping of the application domains. Some additional references for this part:

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171

Castelló Ferrer, E., Rudovic, O., Hardjono, T., & Pentland, A. S. (2018). "RoboChain: A Secure Data-Sharing Framework for Human-Robot Interaction." eTELEMED conference.

Teslya, Nikolay, and Alexander Smirnov. "Blockchain-based framework for ontology-oriented robots' coalition formation in cyberphysical systems." MATEC Web of Conferences. Vol. 161. EDP Sciences, 2018.

* AI: the authors should introduce in a sentence or two the main role of general AI and perhaps its relation to machine learning.

* Discussion: while I like the current discussion, it lacks focus. I understand that more space would be needed to properly outline the main potentials of blockchain in combination with robotics and AI. I suggest that the authors identify 3-4 main potentials of blockchain for improving the current robot solutions and AI within, and focus on discussing those. What is missing and needs be included is the limitations of blockchain within robotics/AI. Again, 2-3 main points should be clearly mentioned.

Overall, this is a nice overview paper; some parts are described in too much depth and can be communicated in a shorter and more focused way. I suggest that the authors work on that, also to get more space for the discussion part. Finally, the authors should have followed the guidelines for the length of the paper (6 pages?). In the final version, they will need to stick with the page limit.

1B. Authors' Response

Reviewer A:

This paper presents a broad survey of applications of blockchain technology in Robotics, AI, cyberphysical systems, and more. The authors conclude the paper by briefly discuss how blockchain could be applied to robotics and AI.

This paper is not written as a scientific contribution. The language is colloquial, the structure is not adequate, and the largest portion of the paper (sections 2.2 and 2.3, over 6 pages) are completely out of topic with respect to what they should discuss in a symposium for robotics. The paper is also well beyond the mandated limit of 6 pages, being 15-pages long.

- We've revised the language and adapted it to be more suitable for a review scientific contribution. We also reduced the number of pages to 6 by removing the sections suggested (2.2 and 2.3) as they were more focused on artificial intelligence. With this, we reduced the length of the paper and focused more on contributions in which the main focus is robotics.

Another major issue of this paper is that it surveys existing work acritically. From reading this paper, it is unclear what might be the hurdles to introduce blockchain into robotics, how robotics is a different domain from the current Bitcoin network, and what are inherent technological limitations blockchain has today that must be overcome. Instead, the paper reads like a sort of advertisement piece for blockchain as a generalist technology.

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171

- The description of the papers has been shortened and the language adapted, becoming more critical. The rest of the review has been analysed and commented on in the discussion part of the paper.

Reviewer B:

This work presents an overview of the current state of blockchain technology in the robotics/AI field. This work is indeed relevant to the Blockchain/Robotics community as well as for the audience of this symposium. However, several points have to be improved in order to reach acceptable quality. In the following lines, I will propose several recommendations and changes:

- Your language is very colloquial and full of subjective and personal judgements. For instance, page 11 “Although this will certainly be a fact in the near future, ...” You should only make judgements/statements based on the references you have (since you are writing a review/overview). Please refer to other review papers and get inspiration in order to use the same type of objective language.

- We agree with the review and we've made changes to the language used and the statements presented to improve the quality of the paper and remove the personal judgements.

- The paper introduces 3 different sections where the state of the art is evaluated. You should also provide an overview of the limitations and future improvements that each one of these fields have/need.

- Although we agree, we've followed the suggestion of reviewer A and removed all the sections that are not mainly focused on robotics. However, we introduce limitations of integration Blockchain with technologies such as robotics and AI in the discussion and introduction.

- Page 5, second paragraph - As far as I know stock exchange data is public. You should clarify the following statement: “only a few data scientists have access to the raw data”

- The statement is no longer present in the paper. But that statement followed what Numerai presents in their paper. Processed and cared data from the stock market is normally very restricted, as one entity wants to monetise that data.

- Page 12, discussion – “Blockchain has the power to store huge amounts of data ...” This is a very questionable statement. Mainstream implementations of blockchain (bitcoin, ethereum,

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171

etc.) have a significant problem with bloat and therefore it is commonly understood that data should be stored off-chain. Please clarify your statements about this issue.

- As part of the length reduction of the paper, that statement was removed from the paper, as it was not totally explicit and could lead to misunderstandings.

- Page 13, discussion, first paragraph - You should mention the possibility/impossibility of reaching a blockchain system that can obtain real-time capabilities. This is an important feature for current and future robotic systems. Please refer to this when you make a statement about the synergy of these two fields.

- We've added it to the discussion. Real-time capabilities in blockchain are not possible today, as far as we know, mainly because the time that a transaction takes to be validated and propagated to the whole network. But this does not mean that in the future it cannot be achieved.

Reviewer C:

This paper overview advances in blockchain technologies and focuses on their application in AI and robotics. The paper is well written and the main ideas communicated, given the space limit. I am in favor of accepting this paper but would like that the authors work on improving some aspects of the papers before it can be accepted.
* robotics part: the authors focus on a few cases of robot uses. It would be better to have a clearer segmentation of robotics domains (based on the type of industries where they are deployed), *e.g.*, manufactories, automotive industry, social robots, etc. This can be done by shortening the description of the referenced papers and doing a more focused grouping of the application domains. Some additional references for this part:

Castelló Ferrer, E., Rudovic, O., Hardjono, T., & Pentland, A. S. (2018). "RoboChain: A Secure Data-Sharing Framework for Human-Robot Interaction." eTELEMED conference.

Teslya, Nikolay, and Alexander Smirnov. "Blockchain-based framework for ontology-oriented robots' coalition formation in cyberphysical systems." MATEC Web of Conferences. Vol. 161. EDP Sciences, 2018.

- We have shortened the description of the papers so that we include the suggested references. Although, we did not separated the the robotic domains because the work that is being done in integrating blockchain and robotics is still incipient and it'd be very monotonic.

* AI: the authors should introduce in a sentence or two the main role of general AI and perhaps its relation to machine learning.

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171

* Discussion: while I like the current discussion, it lacks focus. I understand that more space would be needed to properly outline the main potentials of blockchain in combination with robotics and AI. I suggest that the authors identify 3-4 main potentials of blockchain for improving the current robot solutions and AI within, and focus on discussing those. What is missing and needs be included is the limitations of blockchain within robotics/AI. Again, 2-3 main points should be clearly mentioned.

Overall, this is a nice overview paper; some parts are described in too much depth and can be communicated in a shorter and more focused way. I suggest that the authors work on that, also to get more space for the discussion part. Finally, the authors should have followed the guidelines for the length of the paper (6 pages?). In the final version, they will need to stick with the page limit.

- The discussion section has been adjusted to correspond to the suggestions as far as possible (length restrictions). The paper length was reduced to 6 pages by removing any paper that is not directly focused on robotics and by reducing the description of the papers presented. We also included in the discussion part (table 1) some references that indirectly work with robotics that go accordingly with the suggestions.

ISSN 2379-5980 (online)
associated article DOI
10.5915/LEDGER.2019.171