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All deadlines are 23:59:59 Pacific Time. Current time 07:41:57

Author Tong Yang 255613. Your current session expires in 59:38

Number	21-0448 (ID 21-0448)
Title	An Improved Maximal Continuity Graph Solver for Non-repetitive Manipulator Coverage Path Planning
Authors	Yang, Tong (255613), Valls Miro, Jaime (106478), Wang, Yue* (156231), Xiong, Rong (113216)
Current version	1
Status	Revise and resubmit as Regular [RR]
Required action by the corresponding author	Resubmit not later than April 12, 2022
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Reviews of Version 1. Reviewed for publication as Regular Paper

Review ID	Reviewer number	Comments to the author	Attachment
79503	1	Summary: The presented paper is addressing the coverage path planning with a non-repetitive manipulator. This work is motivated by a non-revisiting coverage path planning (NCPP) approach for manipulators. Latter is based on graph coloring approaches which tend to grow exponentially when searching for optimal solutions. This work proposes to reduce the complexity by taking into account topological-invariance at the color intersections.The complexity is argued to be reduced by the order of 2^N, where N is the number of topological edges. Experimental results are reported from simulation on two arbitrary shaped objects. Comments: - Figure 1b nicely gives the intuition behind topological intersections and introduces the optimality notion in the context of less lift-offs of the manipulator. - Section II ise well organized and gives in detailed explanation along with examples to elaborate more on introduced terms. Proofs to lemmas are mathematically sound. Nevertheless, a paragraph on the original NCPP would be a nice addition to this section. - The analysis of complexity is mathematically sound and presented in adequate detail. - The experimental results are based on the simulation on a hat-like concave hemisphere and a saddle surface. It looks like though from the perspective of segmentation the manipulator motion is not very intuitive. Maybe a more complex object would have been more beneficial to consider in this case, since the hat-like shape for example intuitively could probably be painted with only one color with circular motion. But if it is not the case, it would be great to elaborate on why those shapes are good test sample examples. - Throughout the paper the algorithm is referred to as NCPP, but at the beginning it was defined as the original version from paper [1]. Maybe	

		it could be better to use different terms for the proposed approach in this paper? - On page 10 when mentioning naive enumeration proposed in the literature, please put a reference to that work. - On page 10, please elaborate in short what you mean by minor abuse of notation in this context. - In the appendix Lemma 22 is without proof, it will be useful to have reference to the proof if it is available in literature. Minor: - Page 2: posissible solutions -> possible solutions - Page 8: Fig 13 is referencing to Fig 14 that comes after, possibly change the order. - Page 10: results for the others -> results for the other - Page 11 : Earlier work has proven that [23] the number -> Earlier work [23] has proven that the number	
79505	2	This work addresses the non revisiting coverage path planning problem for a manipulator arm on an object's surface while minimizing the number of end-effector lift offs. The creation of intersection free graphs and their recombination to solve NCPP in a computationally efficient way is interesting. The paper introduces the concept of intersections and their properties and then builds a graph division strategy to create a bottom-up solution to NCPP. The authors add a proof for the claimed computational efficiency and show two simulated examples. While the contributions seem promising, the paper writeup and organization need considerable work. There are two major problems with the paper writing. First, the manuscript is not self-contained in its current form. The paper cannot be understood fully without reading reference [23] which is authors previous work on the problem. The authors don't even include an explicit problem formulation in the paper. Important building blocks for the problem have been pushed to the appendix and should be included within the main text. Second, it is hard to follow the flow of ideas in the current draft. The writing can be considerably improved to make it concise and highlight the creation of intersection free regions for cell decomposition and painting. Authors should consider moving most of the proofs to the appendix to avoid disrupting the flow. The paper also has many grammatical errors and long unnecessarily complicated sentences, that make it hard to read and confuses a reader. For instance: - Corollary 7: No algorithm that can solve a graph with explicit intersection-decreasing, such as transforming an intersection-n graph to an intersection-(n - 1) partly-solved graph. - It can be thus concluded that any graph solvers (including all existing solvers, and the one to be proposed in this work) will face an enumerative scheme, where there is no guarantee of an explicitly decreasing number of intersections as a graph gets gradually solved. - Lemma 22: Different parts of a cell may be painted with different colours provided that the design of the cell-cutting paths satisfy that: 1) It is sufficient to consider cutting paths that start and end at the edge endpoints. 2) It is unnecessary to consider cutting paths that go across edges. 3) It is unnecessary to consider intersecting cutting paths. Can the authors comment on the trade-offs to achieve this computationally efficient NCPP solution with minimal lift-offs. It will be interesting to see how does the approach developed in this paper affect the path length as compared to other approaches to NCPP or that of [23]. An ideal solution should not affect the path length since the coverage is non-repetitive. Other Comments: The introduction does not motivate the problem sufficiently. The text starting from " Given the object' s surface, the manipulator, the surrounding ... " to "... critical such as painting [4], deburring [5], welding [6], scanning [7] etc" justifies why lifting is undesirable. However, it does not make it clear why non-repetitive coverage is	

		useful in the given context. The last few paragraphs of Section I should preferably be moved to a different section on problem formulation and the problem construction must be explicitly defined. Without a problem formulation and motivation for the problem, the paper is difficult to understand. Additionally the authors should also add a list of contributions to the paper. last paragraph, page 2: The authors motivate and justify their solution strategy as a betterment of the cell-division and enumeration strategy that they developed in [23]. What is that cell division? Authors use that cell division in figure 2 and it is not apparent to a reader without reading [23], what exactly is happening in figure 2. It is not clear from the text if lemma 22 is a contribution of this paper. If it is, then the authors must give a proof. If not, then the authors must make it apparent in the text in the appendix. In the current form it is not clear. Also, the text of the lemma is grammatically incorrect as pointed above. In the current state, the paper is hard to read and confusing. It needs more work to improve the writing. While the contribution seems promising, I cannot comment further on the correctness of the technical content in the current form. The authors should reorganise the paper and revise the writeup thoroughly to make it clear and concise.	
79509	4	While the paper may have some good ideas, it is very poorly written. The lemmas and theorems are not mathematical in nature. The results do not sufficiently validate the claims. Some comments: 1) Introduction is too long and confusing. It is suggested to create multiple subsections in the Introduction: Motivation, Challenges, Relevant Work, Proposed Method, Contributions, Paper Organization. 2) The paper cites very old papers for CPP. Many new papers are missing. 3) I wonder why so many conference papers are cited while their journal versions exist. 4)Section 2: please define topological invariant variable in your problem context. " A topological invariant variable .....altogether" is vague and high level. Please give precise definitions as needed. 5) Definition 1: what class of distribution? moreover the defn itself is confusing. 6) Proposition 2: What graph? what cell? homotopic cutting paths? please define them first before using them. 7) lemma 4: This does not sound like a mathematical statement. More like a fact. 8) Corollary 5: This does not sound like a mathematical statement. Also, the proof is long and unclear. 9) Lemma 6: what 0 and 1? I know they are discussed before but never defined. Also, what do you mean by "not countable"? Do you mean uncountable infinite? Thats not true. 10) corollary 7: This does not sound like a mathematical statement. 11) definition 9: what is "boundary of the graph"? 11) Theorem 11: This does not sound like a mathematical statement with a mathematical proof. 12) I didnt see any section with the title "Proposed Method" ?? 13) The experimental results dont show any performance measures such as total time? Only number of iterations are shown.	

Publication decision on Version 1 — October 14, 2021 06:22:59 Pacific Time

Decision	Revise and resubmit as Regular paper [RR]
Cover message	Dear Prof. Yue Wang, Your paper 21-0448 "An Improved Maximal Continuity Graph Solver for Non-repetitive Manipulator Coverage Path Planning" by Tong Yang, Jaime Valls Miro, Yue Wang, Rong Xiong Regular Paper

submitted to the IEEE Transactions on Robotics (T-RO) has been reviewed by the Associate Editor and selected Reviewers. The reviews of the paper are attached.

=== Begin Associate Editor Comments ===

This paper is about non-repetitive coverage planning with maximal continuity performed by a non-redundant manipulator. The approach is based on graph coloring, with a reduction in complexity by accounting for certain topological invariants. Though the reviews note certain merits of the paper, particularly with regard to the overall approach, they also call attention to serious issues with the manuscript. Thus, a thorough revision is needed for the paper to have a chance of being suitable for publication in the Transactions on Robotics. Most importantly, the reviews note that the organization and presentation of the paper can often be difficult to follow, to an extent that the technical content is challenging to understand and to evaluate. Thus, the authors are encouraged to:

- Ensure that the manuscript is self-contained, particularly in the sense of being intelligible for readers that have not read the authors' prior work in reference 23. This will require, among other things, a precise statement of the problem to be solved in terms of its inputs and outputs, and clear and precise definitions of all of the relevant terminology within the main text of this paper.

- Deeply revise the technical exposition, particularly with an eye toward ensuring that the definitions, lemmata, theorems, and other elements are precise, mathematical statements.

- Restructure the introduction, to ensure that the motivation for the work is persuasively presented, that contributions of the paper are directly stated, and that the structure of the introduction is clearly discernible.

- Expand the evaluation to include more complex objects that more clearly demonstrate the effectiveness of the approach.

- Update the references to include more recent results on coverage path planning, and to refer to the latest versions of work that has appeared in journals.

In addition, the reviews provide a number of specific suggestions for additional clarification and correction that the authors should address.

=== End Associate Editor Comments ===

On the basis of the reviewers' ratings and comments, we regret to inform you that your paper in the present form cannot be published in the Transactions. However, you are encouraged to submit a revised version of your work addressing the reviewers concerns. The revised paper will be handled as a new submission that will be reviewed accordingly while keeping track of the previous review material.

If you decide to resubmit, please consult the T-RO website http://www.ieee-ras.org/publications/t-ro for instructions on electronic resubmission. The revised manuscript should be formatted so that any changes can be easily identified by the reviewers, by using, e.g., colored or bold text to indicate revised passages. In addition to the largely revised version of your paper, you should upload also a single pdf file containing your reply to the reviewers' comments and the list of changes made in the paper.

If you have any related concern, do not hesitate to contact me.

Sincerely,

Wolfram Burgard
Editor
IEEE Transactions on Robotics