From: **Transactions on Signal Processing** onbehalfof@manuscriptcentral.com
Subject: ((RQ)) T-SP-23725-2018 - IEEE Transactions on Signal Processing - "A Scalable M-Channel Critically Sampled Filter Bank for Graph Signals"
Date: October 4, 2018 at 9:39 AM
To: dshuman1@macalester.edu
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TO

04-Oct-2018

Prof. David Shuman
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1600 Grand Ave.
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Paper:T-SP-23725-2018, "A Scalable M-Channel Critically Sampled Filter Bank for Graph Signals"

Dear Prof. David Shuman,

I am writing to you concerning the above referenced manuscript, which you submitted to the IEEE Transactions on Signal Processing.

Based on the enclosed set of reviews and my own reading of the paper, I have decided your manuscript requires a MAJOR REVISION (RQ). The reviewers recognize the merits (notably the scalability) and novelty of the proposed M-channel critically sampled filtered bank for decomposing and processing graph signals, and offered detailed comments and suggestion to improve the paper. I concur with this general impression and think that the paper is overall in a good shape to potentially be published in these Transactions. I encourage to take into account these suggestions as you prepare a revised version of the paper, and in particular focus on clarifying the impact of the proposed approach in applications (for instance one reviewer questions the usefulness of the approach). As several of the reviewers suggest, it would be worthwhile to consider including an additional test case involving a realistic application along with performance comparisons against competing alternatives. I think this will markedly strengthen the publication merits of the paper.

Your revised manuscript must be submitted back to ScholarOne Manuscripts https://mc.manuscriptcentral.com/tsp-ieee no later than 6 weeks from the date of this letter together with a required point-by-point reply that explains how you addressed the reviewers' comments. If we do not receive your revised manuscript within 6 weeks from the date of this letter, your manuscript will be considered withdrawn.

After you finish revising your manuscript, please log into your Author Center at https://mc.manuscriptcentral.com/tsp-ieee to upload the new file(s) to your submission. You will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision."

When submitting your revised manuscript, please make sure to also upload your required "response-to-reviewers" file. You can upload this file in the section marked "Respond to the Decision Letter" or to the "File Upload" section. It must be uploaded as a separate file from your manuscript file. Please do NOT upload it to the "cover letter" field as the AE/reviewers do not have access to that section.

Please remember that the Associate Editor should only decide RQ (major revision) once during the peer review process of any paper. Subsequent decisions after one RQ should be AQ, A, or R only.

If you have any questions regarding the reviews, please contact me. Any other inquiries should be directed to Adrienne Fisher.

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Best regards,

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Reviewer Comments:

Reviewer: 1

Recommendation: RQ - Review Again After Major Changes

Comments:
Please find my comments in the attached paper.

Additional Questions:
1. Is the topic appropriate for publication in these transactions?: Excellent Match

1. Is the paper technically sound?: Yes

2. How would you rate the technical novelty of the paper?: Somewhat Novel

3. Is the contribution significant?: Significant

4. Is the coverage of the topic sufficiently comprehensive and balanced?: Yes

5. Rate the Bibliography: Satisfactory

1. How would you rate the overall organization of the paper?: Satisfactory

2. Are the title and abstract satisfactory?: Yes

3. Is the length of the paper appropriate? If not, recommend what should be added or eliminated.: Yes

null:

4. Are symbols, terms, and concepts adequately defined?: Yes

5. How do you rate the English usage?: Satisfactory

Reviewer: 2

Recommendation: RQ - Review Again After Major Changes

Comments:
The authors propose a scalable M-channel critically sampled filter bank to represent graph signals. The key contribution of the manuscript is to propose a scalable solution for graph signal representations and test on a dataset with over 400K nodes. The manuscript is well-written. In general, this is a very interesting and promising work. One major concern is that the current manuscript describes the overall design procedures without in-depth analysis.

Here are some comments to improve the manuscript.
1) This design of the critically sampled filter banks is implemented in the graph frequency domain and favors band-pass graph signals. It would be interesting to explore some theoretical results and show (a) how does graph spectrum partition (ideal graph filter design) influence the representation performance; (b) if any optimal partition strategy exists; (c) how does this design promote sparsity for general piecewise-smooth graph signals.

2) I feel Section IV is quite engineering. Many designs in fast M-CSFB transform are either heuristic or following from previous works without rigorous principles. For example, what is the estimation error of the spectral density by using equation (13); what is the approximation error of the band? If Equation (12) is the overall evaluation metric, how much we can get by using the proposed approximation solution?

3) The signal-adaptive sampling strategy looks very interesting. However, one concern is that when we deal with a huge number of graph signals, is this adaptive method still scalable? Instead of working with each individual graph signal, one potential solution could be dealing with a class of similar graph signals. For example, 1) compute and store a few predefined typical sampling patterns first; 2) use a cheap classifier or clustering method to assign a coming graph signal to one of the typical sampling patterns; 3) use the stored sampling weights to sample a

graph signal.

Additional Questions:
1. Is the topic appropriate for publication in these transactions?: Excellent Match

1. Is the paper technically sound?: Yes

2. How would you rate the technical novelty of the paper?: Somewhat Novel

3. Is the contribution significant?: Moderately Significant

4. Is the coverage of the topic sufficiently comprehensive and balanced?: Yes

5. Rate the Bibliography: Satisfactory

1. How would you rate the overall organization of the paper?: Satisfactory

2. Are the title and abstract satisfactory?: Yes

3. Is the length of the paper appropriate? If not, recommend what should be added or eliminated.: Yes

null:

4. Are symbols, terms, and concepts adequately defined?: Yes

5. How do you rate the English usage?: Satisfactory

Reviewer: 3

Recommendation: AQ - Publish With Minor, Required Changes

Comments:
This paper proposes an M-channel critically sampled filter bank for graph signals. Although the main idea about overall scheme and node selection method are initially suggested in [27], the fast CSFBs are attractive. In particular, the idea of using Jackson-Chebyshev approximation and spectral density estimation to avoid full eigendecomposition of the graph Laplacian is interesting. Furthermore, the paper is well written and organized. My main comments and concerns are as follows:

The main concern about the paper is the authors do not examine the performance of the M-CSFBs in realistic applications. The fast transforms use much approximation, and therefore, the reconstruction error seems to be significantly large compared to the conventional methods (in Table I and Fig. 11). The error might exert adverse effects on the performance. The author should apply the proposed transform into an application, such as compression and denoising, and compare the performance with the diffusion wavelets, graphQMF, and graphBior.

Two-channel critically sampled transforms, such as graphBior and graphQMF, can achieve similar (octave-band) decomposition to that of M-CSFB by applying the transform into output lowpass signals iteratively. What is the main advantage of the M-CSFB compared to these transforms?

In Table II, why is the computation time of graphQMF quite larger than that of the fast M-CSFBs even though both of them use the 50th order polynomial approximations?

The approximation orders used in this paper look like very large when we take the computation cost and localization in the vertex domain into account. It would be nice to show the reconstruction error of the M-CSFB with lower order approximation.

Additional Questions:
1. Is the topic appropriate for publication in these transactions?: Excellent Match

1. Is the paper technically sound?: Yes

2. How would you rate the technical novelty of the paper?: Somewhat Novel

3. Is the contribution significant?: Moderately Significant

4. Is the coverage of the topic sufficiently comprehensive and balanced?: Yes

5. Rate the Bibliography: Satisfactory

1. How would you rate the overall organization of the paper?: Satisfactory

2. Are the title and abstract satisfactory?: Yes

3. Is the length of the paper appropriate? If not, recommend what should be added or eliminated.: Yes

null:

4. Are symbols, terms, and concepts adequately defined?: Yes

5. How do you rate the English usage?: Satisfactory

Reviewer: 4

Recommendation: AQ - Publish With Minor, Required Changes

Comments:
In this paper the authors propose techniques to decompose a graph signal into M components, each of which corresponds to a frequency subband of the graph frequency spectrum. Their approach is to use an M-filter bank followed by downsampling in each of the subbands. Downsampling here corresponds to selecting a subset of the graph nodes which is a uniqueness set for the given frequency band. While performing these operations is straightforward if one has the eigendecomposition of the graph Laplacian, that is typically computationally expensive. The paper introduces a number of techniques aimed at circumventing this computation.

In my understanding, there are three main ideas. (1) First we estimate the spectral density of the graph rather than performing the eigendecomposition. This allows one to define the band ends in a way that splits the eigenvalues evenly (or in whatever proportions are desired). Given the band ends, one can can define ideal bandpass filters, but in order to apply the filters, one would once again need the eigendecomposition. (2) The second main idea is then to approximate the ideal filters using Chebyshev polynomials. This allows one to compute an approximation to the filtered graph signal in a given band without the eigendecomposition of L. (3) To pick the set of nodes for downsampling of each bandpass filtered signal, non-uniform random sampling is applied (following the approach in [33]).

In addition to that, the paper presents many other ideas such as a way to pick the band ends at points of low spectral density, an optimization-based reconstruction step (which again avoids the eigendecomposition through a carefully chosen penalty term), and a way to modify the non-uniform random node selection in a way that adapts to the specific signal. Overall, the paper is an impressive combination of techniques, all of which are interesting. But one criticism I have is that there are so many pieces that it is difficult for the reader to figure out what the key contribution is. For instance, does the discussion on the different phi_m's for the reconstruction penalty term add anything to the paper (given that it's based on [33])? Does updating the band ends to move towards lower spectral density help?

In terms of the empirical results, the most exciting part to me is that their proposed approach is the only technique that was able to handle the large temperature dataset, while other approaches did not finish. I believe that this should have been emphasized a bit more, as the main motivation for this work is to avoid the O(N^3) scaling of the eigendecomposition.

Other than this, I thought the empirical results were a bit unconvincing and a bit distanced from practice. What is the practical goal of any of these experiments? Is it to compress graph data? But if you are still storing a total of N transform coefficients, there is no compression, right? More discussion on the potential applications of this would be helpful. Moreover, the reader wonders if several of the techniques introduced actually affect the reconstruction MSE. For instance, does the careful choice of band ends (by first estimating the spectrum and then moving the band ends to low spectral density points) improve the results significantly? What if you just pick band ends arbitrarily? Also, if you just use uniform random sampling to pick the nodes, are the results significantly worse? While all these steps are well motivated conceptually, I would like to see their impact.

Overall, I find the paper interesting, and I think the contributions are of interest to the community. The paper is well written and clear, and technically sound to the best of my knowledge. But I would like to see some discussion on why this approach is useful.

Some other minor comments:

1) atom should be defined when it's first mentioned
2) Why is it relevant whether the atoms are localized in the vertex domain?
3) In (12), is the first equality really an equality? I didn't understand that.
4) Why is it that signal-adapted sampling for a low pass signal (Figure 11) has a worse NMSE than non-adaptive? That seems weird.

Additional Questions:
1. Is the topic appropriate for publication in these transactions?: Excellent Match

1. Is the paper technically sound?: Yes

2. How would you rate the technical novelty of the paper?: Somewhat Novel

3. Is the contribution significant?: Significant

4. Is the coverage of the topic sufficiently comprehensive and balanced?: Yes

5. Rate the Bibliography: Satisfactory

1. How would you rate the overall organization of the paper?: Satisfactory

2. Are the title and abstract satisfactory?: Yes

3. Is the length of the paper appropriate? If not, recommend what should be added or eliminated.: Yes

null: I do think the authors describe a lot of the details of the algorithm, when it's not clear how relevant they are to the message. But I don't think it's excessively long.

4. Are symbols, terms, and concepts adequately defined?: Yes

5. How do you rate the English usage?: Satisfactory

Reviewer: 5

Recommendation: AQ - Publish With Minor, Required Changes

Comments:
In the paper “A Scalable M-Channel Critically Sampled Filter Bank for Graph Signals” authors built on and expand their previous work. In a nutshell authors devise a method to efficiently subdivide Laplacian bandwidth of a graph signal into M subbands and efficiently construct synthesis/analysis atoms based on these division. Main tool used by the authors is an application of extended Chebyshev polynomials for filter bank construction. In the paper they address both signal adapted and signal independent scenarios. From the application perspective authors provide several algorithms for sampling and subband selection that were taken from recent works on random sampling.

The paper is very well and accurately written. Overall I have only several minor corrections:
1. page 2, line 28: Combinatorial graph Laplacian is usually not weighted (see works e.g. of F.R.K Chung for reference), therefore I propose to remove the word “combinatorial”
2. page 2, Lemma 1: Probably S should be written in caligraphic

Additional Questions:
1. Is the topic appropriate for publication in these transactions?: Excellent Match

1. Is the paper technically sound?: Yes

2. How would you rate the technical novelty of the paper?: Somewhat Novel

3. Is the contribution significant?: Significant

4. Is the coverage of the topic sufficiently comprehensive and balanced?: Yes

5. Rate the Bibliography: Satisfactory

1. How would you rate the overall organization of the paper?: Satisfactory

2. Are the title and abstract satisfactory?: Yes

3. Is the length of the paper appropriate? If not, recommend what should be added or eliminated.: Yes

null:

4. Are symbols, terms, and concepts adequately defined?: Yes

5. How do you rate the English usage?: SatisfactoryReview.pdf