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gbsv Mini-Challenge 1

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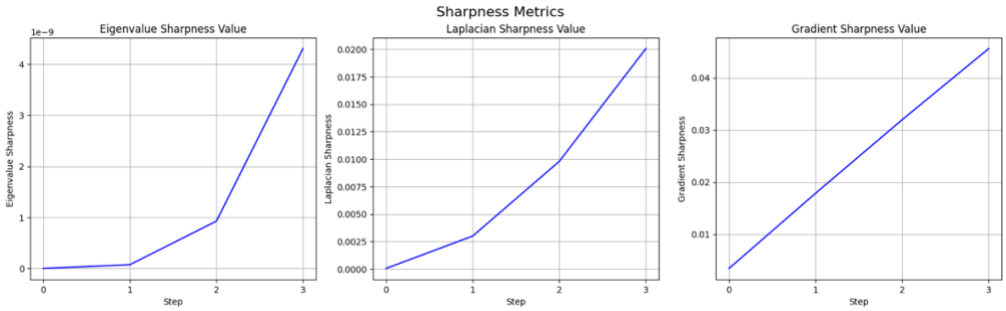
1 Notable Results

As I embarked on my journey through Sweden, I found myself intertwining the breathtaking landscapes with a profound exploration of image and signal processing. My notebook was not only a scientifical endeavor, but also a nostalgic revisit of the country a part of my family is from.

In my experiments with **Image Properties**, I was captivated by how easily metrics can record change in the signals. The Northern Lights, initially a blurry spectacle, transformed, revealing clearer outlines of the auroras and trees. Similarly, the ancient Stone Circle in Kiruna unveiled the mysteries of the ground's topological structure, once hidden beneath the snow. The Stora Sjöfallets Nationalpark presented a unique challenge with its noisy image of Akkajaura Lake, pushing me to test the stability of sharpness metrics in such conditions.

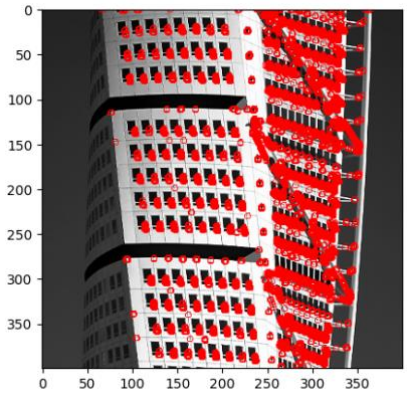
During my exploration of image sharpness metrics, I discovered a surprising gap in resources. The existing metrics felt limited and unsatisfactory for my objectives. This challenge inspired me to develop my own metric, the "Gradient Sharpness".



Venturing into **Signal Properties**, I played with sounds and their underlying properties. Using familiar tunes like "Små Grodorna" and "Dancing Queen", I explored phase shifts, bandwidth, and the intricate nuances of the Nyquist-Shannon Theorem. This journey through sound was both very insightful and musically nostalgic.

The experiments in **Filtering** introduced me to the transformative power of filters in image and signal processing. A particularly intensive exploration was in wavelets. I was determined to detect structural damages in streets, a real-world application that could have profound impacts on urban planning and safety. In my example I took an image of the Öresund Bridge which connects Denmark with Malmö, Sweden.

One of my proudest achievements was demystifying the **Harris Corner Detector**. Using this renowned method, I was able to detect corners in images.



2 Discussion

Measuring Image Properties:

Advantages: The experiments with the Northern Lights, Stone Circle in Kiruna, and Stora Sjöfallets Nationalpark demonstrated the potential of enhancing image sharpness, resulting in visually clearer images. The introduction of the Gradient Sharpness metric offered a novel approach to quantify sharpness.

Limitations: Sole reliance on metrics, especially without visual validation, can lead to potential over-enhancements. The eigenvalue metric's behavior, in comparison to others, hinted at inconsistencies. Generally, it is also important to note that metrics often do not represent human perception, so while a metric might capture a mathematical change, we might not see it in the plot.

Comparison with Expectations: While there was a clear improvement in image clarity, the behavior of some metrics diverged from initial expectations. More extensive tests or benchmarks might be needed to validate these metrics against established ones. I would've wished to have more time to explore further approaches on explicit sharpness measures. Another plan I had in the beginning was to negative-test the measures, so changing an image properties that were uncorrelated to sharpness and then applying the metrics to see how isolated they view sharpness.

Measuring Audio Properties:

Advantages: The experiments provided clarity on the intricacies of sound signal manipulation, showcasing the practical application of theoretical concepts.

Limitations: A deeper dive into real-world challenges concerning sound quality and fidelity across diverse scenarios was missing. To that, I believe that someone with more expertise could've made more critical statements based on the metrics as they sometimes behave very unpredictably.

Comparison with Other Works: While the foundational concepts were well-covered in my opinion, incorporating more advanced sound manipulation techniques or comparisons with state-of-the-art methods could offer a broader perspective. Something I was not very satisfied with was my exploration of the Distortion property. I had a very hard time making out what distortion is, so I objectively tried to cover every definition I found – which is not the cleanest way of doing scientific exploration.

Spatial Filtering:

Advantages: Spatial filtering is much less complicated than filtering in a domain that is not directly viewable or tangible for human perception. It can be super easy to reproduce and trace a filter's behavior.

Limitations: Implementing filtering algorithms oneself in a shorter timeframe introduces complexity challenges. We apply two dimensional operations on large two-dimensional planes which can take up a lot of computing power. My implementation seemed to grow linearly with an input-image's size.

Comparison with Expectations: I am sure if I made more profound use of numpy's precompiled matrix functionalities I could've come up with a faster solution – probably even implementing a vectorized approach would've made it much better.

Wavelets for Structural Detection:

Advantages: Wavelets effectively captured structural nuances, showing promise in detecting damages.

Limitations: The diverse patterns and textures in streets can introduce complexities not addressed in the experiment.

Comparison with Expectations: While wavelets showed potential, the results indicated room for refinement, especially when benchmarked against specialized damage detection systems. A more intricate experiment or exploration on more sophisticated street-imagery would've maybe better captured further rooms for improvement.

Wavelets for Compression:

Advantages: The view on the **spatial and frequency domain** doesn't only allow for filtering purposes but also for compression purposes. Wavelet Compression is a common approach, also in real world applications (such as JPEG 2000) to cut down on an image's memory space.

Limitations: My implementation uses a simple thresholding technique that cuts down on components that make out very small details. Sometimes that could mean an image would lose properties of interest. The implementation is also rather rudimentary as it doesn't cover compression in the sense of file-size reduction.

Comparison with Other Works: When comparing this work with actual real-world implementations, it is apparent that those are way more sophisticated but probably less insightful. I would see more opportunities to improving it by showing more examples – I only showed a single image's compression.

Corner Detection:

Advantages: The Harris Corner Detector's application on the Turning Torso structure effectively demonstrated corner detection in complex structures. It is a straightforward algorithm that can be implemented in an easy manner.

Limitations: Real-world challenges like varying lighting and overlapping structures can compromise detection accuracy. This is also where my implementation still was lacking. It did detect corners, but only those who had very clear cuts when it comes to contrast.

Comparison with Other Works: The experiment's results aligned with established corner detection techniques but incorporating preprocessing steps (such as histogram equalization etc.) might enhance performance by a noticeable amount.

3 Reflection

At first the Challenge didn't look like it would cost me an extreme amount of time, but I love giving attention to detail and the way the tasks were formed really allowed me to explore deeply into each different part of Signal Processing. But with that openness came a lot of uncertainty. I often had a hard time proceeding onto the next task because there are at least ten other things that could still be improved and reimplemented. So, a key-takeaway for me is to notice when I'm spending too much time on a detail and acknowledge that I must commit to one idea I have.

Personally, I really liked the theme of choosing a country to do Signal Processing on. It allowed for a lot of creativity, which is usually not something we encounter in the Data Science program, and I missed that until now. Personally, I would've wished for more strictly outlined tasks (for example, stating how many experiments, what tools and metrics to use etc.). I spent about eight to nine full days working on this Mini Challenge and thus have exceeded the recommended 45h mark by quite a margin. I could've probably gone another eight days in which I kept on refining my choices and experiments.

In the end though, I am satisfied with what I have accomplished. The learning curve has been immense; therefore, I don't feel too bad about my time investment – I am looking forward to work on the next chapter, Mini Challenge 2!

4 Repository

https://github.com/okaynils/fhnw-ds-gbsv

5 Journal

Day	Description
1	**What have I done today?** Today I familiarized myself with the first task of applying and measuring the sharpness of an image. I tried out different metrics but couldn't find a metric that explicitly measures the property of sharpness. **What worked out well?** I quickly found a lot of different ways to capture the sharpness of an image. **Where and what problems did emerge?** It's quite hard to find the perfect or right metrics for my case, there are countless different resources to choose from. **Who or what could help me resolve these problems?** I resolved this "problem" by just committing to three different metrics. I am measuring all of them simultaneously while applying more sharpness over time. In this way I can see if a metric would make sense.
2	**What have I done today?** After extensive research on different metrics that could potentially fit the purpose of measuring explicitly sharpness, I finally found a resource that helped. **What worked out well?** I have found a paper that discusses the appliance of eigenvalues (i.e., SVD) to quantify sharpness. **Where and what problems did emerge?** The big problem with implementing such an "unknown" principle (the paper only got cited a few times) is that it's not essentially a right or safe choice, so it's hard to make claims based on that metric. **Who or what could help me resolve these problems?** I indirectly implemented a solution to this problem by always looking at more than just one metric.
3	**What have I done today?** Finally, I decided to move on from sharpness and now I was doing research on Noise and Color Spaces. I quickly found ways of applying denoising and color space transformations. **What worked out well?** I didn't have many complications that held me back from proceeding, that was rather motivating. **Where and what problems did emerge?** I spent almost two full days on finding the right metrics for sharpness and I slowly started to notice that I'm probably not going to find any more resources that would give me a more stable metric. **Who or what could help me resolve these problems?** There's not much need for a third-party resource, more just the fact that I need to start committing to my ideas earlier and not "lose" time in perfection.
4	**What have I done today?** Today was a productive day, I was able to build up the structure of the Task 1.2 on the signal properties of one-dimensional signals, such as sound. **What worked out well?** In my opinion I found good ways of plotting my results and experiments. I really focused on the "user friendliness" so that I can reproduce multiple experiments with the same structure. **Where and what problems did emerge?**

	I find myself often in the predicament of choosing between wanting to dive deeper and to continue the next task. The tasks of this challenge are very open and broad so it's hard to define boundaries, at least in my perception. **Who or what could help me resolve these problems?** I talked to other students and asked how deep they describe their findings and experiments and found similar approaches to me so I will probably continue doing work in the structure of Research > Define Metrics and Manipulations > Define Experiment Function > Find data for Experiments > Carry out experiment.
5	**What have I done today?** I worked on implementing the Harris Corner Detection after finding it on Wikipedia as one of the most common approaches to detecting corners. **What worked out well?** The implementation worked with success. The code seems to correctly detect the corners in the images. **Where and what problems did emerge?** I faced problems in finding the "right" parameters (such as threshold) for the Harris Corner Detection. It was a tedious process and felt more brute force like rather than systematic. **Who or what could help me resolve these problems?** Using a more systematic approach to the finding of the "correct" values would probably help me the next time I encounter such a task.
6	**What have I done today?** I finished the wavelet bonus task today, for that I wanted two examples that would also make sense in a real-world case. **What worked out well?** I found, in my opinion, good and senseful cases that apply to the spatial and spectral transformation of signals. After a quick look up on what the Wavelet Transform does, I was able to start coding out my ideas. **Where and what problems did emerge?** I did not encounter any mentionable issues. **Who or what could help me resolve these problems?** No help or resources needed so far.
7	**What have I done today?** Slowly my take on the Mini Challenge 1 starts to take a solid shape and form. For this day I set a goal to come up with solutions for the last couple of exercises that were still open. I primarily worked on trying to explain Standardization, Normalization and Nyquist-Shannon Theorem (Sampling rate). **What worked out well?** I again tried to focus mainly on showing my insights clearly and explaining the results in a clear way. **Where and what problems did emerge?** I did not encounter any mentionable issues. **Who or what could help me resolve these problems?** No help or resources needed so far.
8	**What have I done today?** Today marked the last day of the Mini Challenge. This means I have mainly gone over each exercise again and tried to improve what stuck out to me. **What worked out well?** I took about three days off working on the challenge which inspired me and gave me a couple of new ideas that I weren't thinking of before. I noted these down so that I was able to work on them today – mostly these notes just consisted of how I could improve my way of explaining things inside my notebook.

	Where and what problems did emerge? I once again lost myself a bit in details. **Who or what could help me resolve these problems?** I set a time boundary of when I am going to submit the challenge.