

Math 30720 PAPER/PROJECT, Due Monday, April 23
Choice of topic due by Monday, March 26

If you choose to write a paper, it should be a well-written explanation of the topic and should convince me that you have a good understanding of it. It should not be something copied from a book or paper. It must include at least one proof (either details or a careful sketch of the key steps), description of a kind of wavelet you haven't seen before, or a clear explanation of how wavelets are applied in your topic. Include references. Here are some possible topics, with possible references (with links where possible) to get you started. If you want to do a topic not on this list, please discuss it with me ahead of time.

If you prefer, you can do a computer project. Please discuss it with me ahead of time.

1. Learn about image compression and the JPEG and JPEG 2000 algorithms. How is JPEG 2000 an improvement over JPEG? What have been some of the major applications of JPEG 2000? How would you try to convince manufacturers of digital cameras that they should switch from JPEG to JPEG 2000? ([Au])
2. Learn about reuniting the panels of the Ghissi altarpiece. ([D],[G])
3. How can wavelet transforms be used to in the stylistic analysis of paintings? ([JPBre])
4. How can wavelet transforms be used to detect forgery in paintings ([JPBra])?
5. Learn about the use of wavelet techniques to analyze molecular simulations. ([Abd])
6. Learn about the denoising/reconstruction of cylinder recording of Johannes Brahms performance of a segment of his First Hungarian Dance. Start with "Brahms at the piano" ([B]) and then look at some of the more technical references it mentions.
7. Learn about the use of wavelets for the analysis and synthesis of music. ([K1], [K2])

8. Learn about the use of wavelets in medical imaging. ([UA])
9. Learn about applications of wavelets in economics. ([R])
10. Learn about continuous wavelets. Read chapter 5 of the textbook.
11. Learn some about the development of wavelets. Read ([H])
12. Learn about the use of wavelets in the LIGO detection of gravitational waves. ([Abo1], [Abo2])

References

- [Abd] Abdel-Hafiez, “Analysis of Molecular Dynamic Simulations Using Wavelet-Based Techniques,” *International Journal of Modern Physics and Applications* 2015, Vol. 1, No. 4, pp. 145-151
- [Abo1] Abbott *et al.*, Observation of Gravitational Waves from a Binary Black Hole Merger, *Physical Review Letters* 116, 061102 (2016)
- [Abo2] Abbott *et al.*, Observing gravitational-wave transient GW150914 with minimal assumptions, *Phys. Rev. D* 93, 122004 (2016)
- [Au] Austin, Image Compression: Seeing What’s Not There
- [B] Berger, Brahms at the piano
- [D] Daubechies, ed., Reunited: An art historical and digital adventure
- [G] Reunied: The Ghissi Altarpiece
- [H] Hubbard, *The World According to Wavelets: The Story of a Mathematical Technique in the Making*, on reserve in the Math Library
- [JPBra] Jafarpour, Polatkan and Brasoveanu, Detection of forgery in paintings using supervised learning
- [JPBre] Jafarpour, Polatkan and Brevdo, Stylistic analysis of paintings using wavelets and machine learning

- [K1] Kronland-Martinet The Wavelet Transform for Analysis, Synthesis, and Processing of Speech and Music, *Computer Music Journal*, Vol. 12, No. 4 (Winter, 1988), pp. 11-20
- [K2] Richard Kronland-Martinet: Sound, music and wavelets in Marseille, video of lecture at Centre International de Rencontres Mathématiques (CIRM), 2015
- [R] Ramsey, Wavelets in Economics and Finance: Past and Future, *Studies in Nonlinear Dynamics and Econometrics* 2002, Vol. 6 No. 3.
- [UA] Unser and Aldroubi, A review of wavelets in biomedical applications, *Proceedings of the IEEE*, 1996 Vol. 4, No. 4, pp. 626–638