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AE 457
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Literature/Technology/Professional Environment Review

1. Literature Review
    a. Linear Feature Detection on GPUs
        i. Domanski, L., Sun, C., Hassan, R., Vallotton, P., & Wang, D. (2010). Linear Feature Detection on GPUs. 2010 International Conference on Digital Image Computing: Techniques and Applications. doi: 10.1109/dicta.2010.112
        ii. The paper investigates how to improve the efficiency of linear feature detection within 2D images through the application of GPUs.
        iii. Summary
            1. Linear feature detection has a wide scope of usability, notably within medical, biomedical, and remote sensing contexts.
            2. There are a multitude of methods for linear feature detection:
                a. Directional filters
                b. Tracking techniques
                c. Classification based methods
                d. Profile based methods
            3. If a linear feature is detected, it frequently will have gaps. These gaps need to be accounted for and joined. These gaps may also occur at branching points which can further increase complexity.
            4. Cites another paper that describes a gap filling algorithm, but it has a large time complexity.
            5. The length of a linear window (what is used to index over the pixels of an image) directly affect the sensitivity of an algorithm. For images with dense linear structures, a window that is less sensitive may also miss linear features. A second pass should be performed with a smaller window to handle these situations.
            6. Gaps can be filled by using a shortest path search of feature mask endpoints and seeing if those connect with parts of the feature mask.
            7. GPUs allow for operations to occur in parallel due to their high core counts.
            8. Pseudocode is provided for a dnms dual peak algorithm.
                a. Discuss how to increase GPU efficiency.
            9. Discuss methods for filling gaps with GPUs in parallel.
        iv. Analysis
            1. The usage of GPUs for linear feature detection can greatly improve the efficiency at which features are detected. Furthermore, the detection of linear features can be done in parallel which further increased efficiency. There are also methods

of filling gaps within linear features which should be investigated for relevance within the context of detecting meteors within spectrographs.

v. How this will be used

1. The paper will provide me with a basis for determining desired efficiency of my feature detection algorithm. This determination will then provide me with a basis for required processing power, whether it be just CPU based or if GPUs (or even TPUs) are required. This will also factor into the cost of the overall system. The paper also provides a basis for efficient algorithms for feature and gap filling, which will be extremely beneficial during initial development and scoping as it will provide me with a starting point.

b. Boosting Color Saliency in Image Feature Detection

i. Weijer, J. V. D., Gevers, T., & Bagdanov, A. (2006). Boosting color saliency in image feature detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *28*(1), 150–156. doi: 10.1109/tpami.2006.3

ii. The paper highlights how luminance based feature detection reduces accuracy of feature detection within images because color information is completely ignored.

iii. Summary

1. This method of feature detection in images has been successfully applied to image matching, content-based retrieval, learning and recognition.
2. There is no detection between black-and-white corners from red-green corners in luminance based feature detection.
3. Introducing color saliency boosts repeatability.
4. Extremely math and theory heavy.

iv. Analysis

1. By introducing color saliency to a feature detection algorithm, the success of feature detection can likely increase the effectiveness and robustness of an algorithm. Rather than solely relying on the luminance, color can also be used to detect features within an image, which, for meteor detection within spectrographs is extremely useful as both luminance and color are used to highlight areas of activity.

v. How this will be used

1. This paper can be applied to my project opportunity to help increase the robustness of feature detection by accounting for color within an image. By applying high saliency to red portions of a spectrograph and 0 saliency to blue portions of a spectrograph

color saliency can be used to further restrict the areas of a spectrograph that are being investigated for meteor activity.

c. Automatic feature Learning for Robust Shadow Detection
    i. Khan, S. H., Bennamoun, M., Sohel, F., & Togneri, R. (2014). Automatic Feature Learning for Robust Shadow Detection. 2014 IEEE Conference on Computer Vision and Pattern Recognition. doi: 10.1109/cvpr.2014.249
    ii. The paper discusses a framework that can be used to automatically detect relevant features for shadow detection within images that has better performance than “state-of-the-art” algorithms.
    iii. Summary
        1. Shadows provide useful context clues as to the state of objects which cast them.
        2. Chromatic, textural, and illumination properties of shadows are used to determine the illumination conditions of a scene.
        3. Provides mathematical formulas for the shadow detection framework.
        4. Provides flowchart for how shadow detection framework works.
        5. Discusses how to conduct feature learning with ConvNets (convolutional deep learning network).
        6. Discusses the usage of SMOTE (Synthetic Minority Oversampling Technique) to generate training samples that help to aid representation of a minority class.
        7. Discusses the usage of a smoothness filter, specifically a bilateral filter, before boundary extraction is done to enhance edges within an image.
        8. Provides algorithm for boundary detection and shadow localization.
    iv. Analysis
        1. The usage of feature learning to detect shadows within color images highlights the capabilities of feature learning. The performance achieved with feature learning also highlights how revolutionary a technology it is. Being able to detect and prioritize features that represent desired areas of focus without direct influence reduces human bias and allows for only relevant features to be used to detect shadows within an image.
    v. How this will be used
        1. While shadow detection itself is not relevant to my project, the methods in which shadow detection were obtained can be. Feature learning should be investigated when constructing an algorithm to detect meteors within spectrographs. The methods for detecting edges of shadows, specifically, the usage of bilateral filtering can also be used to increase the sensitivity of edge

detection to further increase the prominence of meteors within a spectrography.

2. Technology Review
   a. Machine Learning for High-Speed Corner Detection
      i. Rosten, E., & Drummond, T. (2006). Machine Learning for High-Speed Corner Detection. Computer Vision – ECCV 2006 Lecture Notes in Computer Science, 430–443. doi: 10.1007/11744023_34
      ii. This paper discusses how to conduct real-time feature detection with less than 7% of the available processing time with a provided PAL video.
      iii. Summary
         1. Feature detection with SIFT, Harris, and SUSAN, all provide high quality features but are too computationally heavy.
         2. Discuss how previous methods of corner detection were computed.
         3. FAST (Features from Accelerated Segment Test) is introduced as a high performance system to detect features within images. However, it has limitations:
            a. Does not generalise well for n < 12 (size of segment)
            b. Has implicit assumptions about the distribution of feature appearance
            c. Knowledge from previous tests are discarded
            d. Multiple features are detected adjacent to one another
         4. Provided time taken and CPU utilization for different algorithms on an Opteron 2.6GHz and Pentium III 850 MHz CPUs.
         5. Discuss how to stitch images together through the use of edge detection.
         6. Discuss advantages:
            a. Many times faster than existing detectors
            b. High levels of repeatability under large aspect changes for different features
         7. Discusses disadvantages:
            a. Does not handle high levels of noise well
            b. Can only respond to 1 pixel wide lines at certain angles
            c. Is dependant on a threshold
      iv. Analysis
         1. The introduction of an efficient machine learning algorithm that can detect corners could not yet be created without drawbacks. The most apparent being that high levels of noise within a provided image result in poor results. This is because of the low amount of pixels being used for corner detection. However, even with this limitation, highly accurate results can be obtained. Unfortunately, this comes at the cost of a limited dataset that requires high quality (low noise) images.

v. How this will be used
    1. The researchers use extremely outdated CPUs, but the methods for edge and feature detection can still be applied to current systems such as a Raspberry Pi or other small low powered systems to decrease overall system usage, decrease processing time, and reduce system costs.
    2. Introducing real-time image processing, data collected can be processed and then analyzed with little to no downtime for researchers.

3. Professional Environment Review
    a. Machine Learning for the Detection of Oil Spills in Satellite Radar Images
        i. [Kubat, M., Holte, R. C., & Matwin, S. (1998). Machine Learning for the Detection of Oil Spills in Satellite Radar Images. Machine Learning, 30(2/3), 195–215. doi: 10.1023/a:1007452223027]
        ii. Machine learning techniques were used for detecting oil spills, during this process, problem formulation, evaluation measures, and data preparation are investigated and determined.
        iii. Summary
            1. The paper investigates methods of detecting oil spills from radar images of the sea surface to decrease environmental damage.
            2. Only 10% of oil spillage occurs from natural sources.
            3. Discusses previous work done to detect oil spills from radar images, specifically that it has always been investigated since the introduction of satellite technologies.
            4. The application of this system could serve as an early warning system, deter illegal dumping of oil, and most importantly, provide a significant environmental impact by reducing ocean exposure to oil.
            5. Discusses method of taking obtained data, pixel image, and processing it for usage, normalizing.
            6. Investigates problem characteristics
                a. Limited by scarcity of data
                b. Limited by imbalanced training set, there are many more false positives (not real oil spills) than oil spills
                c. Performance concerns
                d. Datasets vary greatly
            7. Discusses two additional experimental detection methods, C4.5 and 1-NN, and investigates those outcomes.
            8. Delivered constructed CEHDS (Canadian EnvironmentalHazards Detection System) system to Macdonald Dettwiler Associates.
        iv. Analysis
            1. With a limited and varying dataset, it is possible to construct a machine learning model to detect features within images, however

there are limitations that are introduced due to this. These limitations, such as scarcity of data, resolution of data, and imbalanced training sets can thus decrease granularity of the dataset used to train a machine learning model.

v. How it will be used

1. The methods for scoping a problem that were discussed within the paper can be retrofitted to scope how to properly identify how to detect meteors within spectrographs.
2. Should I be unable to obtain an extensive dataset, the limitations discussed within this paper can be taken into consideration and worked around to help reduce potential interference that it may cause.