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Course I Report

Proposed Application

Image processing and facial recognition are critical players in modern technology, with uses ranging from identity verification to law enforcement. As such, methods of improving pattern recognition technologies through quantum technology can lead to more powerful and efficient pattern recognition that can be used to improve a vast array of fields, such as in biomedical imaging and remote sensing.

Advantages

Several quantum techniques can be used to acquire more useful images for use in facial recognition processing, including quantum illumination and ghost imaging. Quantum illumination is a method of utilizing pairs of entangled photons to reduce the impact of a noisy background in an image, rather than the conventional illumination method of using random, unpaired electrons for illumination. With quantum illumination, improved detection results in more accurate imaging through noise reduction. Similarly, the technique of ghost imaging uses entangled photons to improve image processing. By splitting a light beam into two different paths, the correlation between the two paths can be analyzed to reconstruct the image. This allows processing to form images without directly measuring an object's light. This is useful in applications where excess light may damage the measured sample, such as in biomedical sampling. Both of these quantum techniques mitigate the traditional limits of image processing in facial recognition. By obtaining more accurate images, facial recognition technologies can utilize inputs with more complex data and improve recognition processes.

Of course, it is important to consider advantages in the analysis of images through quantum technologies as well. In particular, a quantum pattern recognition processor utilizes three main subprocesses: quantum principal components analysis (QPCA), quantum independent component analysis (QICA), and quantum dissimilarity measures for comparing faces. These are not entirely new technologies, but rather are simply quantum improvements of the three techniques already used in traditional image processing. All three technologies make use of quantum properties like superposition and entanglement, which enhance analysis efficiency. Integrating these quantum methods into image analysis leads to a greater efficiency compared to traditional image processing. One proposed quantum pattern recognition algorithm can have an overall runtime *N* times faster than traditional pattern recognition algorithms[1].

Performance Needed

Currently, no quantum computers can successfully implement this protocol. The performance requirements for algorithms like these are not yet well-defined. Overall, to get to a stage where these methods can provide an advantage over traditional image processing, it is necessary to improve the computational power of quantum computers. The quantum errors made during quantum computing are one of the largest culprits in undermining quantum computing integrity, so it is imperative that quantum errors be mitigated so that quantum computing can be used to revolutionize fields such as image processing and facial recognition.

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[1] Salari, V., Paneru, D., Saglamyurek, E *et al.* Quantum face recognition protocol with ghost imaging. *Sci Rep* 13, 2401 (2023). DOI 10.1038/s41598-022-25280-5

Also referenced: T. Gregory, *et al.* Imaging through noise with quantum illumination. *Sci. Adv.* **6**, eaay2652 (2020). DOI: 10.1126/sciadv.aay2652