

Research Statement

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I am interested in many research points related to computer engineering and its applications in real life.
The research fields are:

1. Image processing and artificial intelligence applications.
2. Optimization and approximation algorithms for NP-hard problems.
3. Trust and reputation system in the cloud using Blockchain technology.
4. Attitude Determination and Control Systems for cubic satellites.

MSc. Degree Research: Advancements in technologies in the recent ten years brought to us the promising technology of optical character recognition (OCR). There is a big problem when identifying text with different fonts because of the difference between the same letter shapes in different fonts. In my research, I concern with the different characteristics multi-font Arabic machine-printed optical text recognition. This is done by identifying the font type before recognizing the characters which significantly increases the total mean recognition rate of the proposed system.

There were three main contributions in my master research. The first contribution is in the cursive Arabic character segmentation. This was done by designing a constant amplitude (low variations) passing filter. This filter operates on the output of the vertical axis profile of the word. The filter output is a locus of the characters separations. With the aid of this filter, the correction ratio of this algorithm reaches 98%. The second contribution was in the field of the character recognition using scale invariant detectors. This part uses eight techniques to get the best one which is suitable for Arabic OCR. A complete study was performed for all the eight scale invariant detectors and approved that the Harris Laplace is the best one for describing the Arabic characters with the aid of the gradient descriptor and the k-means clustering. The last contribution was in the field of multi fonts Arabic OCR. The proposed optical Arabic font recognition (AOFR) algorithm suggested achieved a correction ratio of 100% over 15 fonts. This algorithm enhanced the mean recognition rate of the character recognition for multi-fonts from 40% to 99%.

PhD. Degree Research: We studied cost optimization in multi-mode systems with discrete costs. We first solved the problem in one dimension and next we studied it in multiple dimensions. As a motivating example, we studied the temperature control in buildings using heating, ventilation and air-conditioning system HVAC while paying the minimal cost as possible. By optimizing the behavior of the HVAC systems, lots of energy could be saved. We were interested in finding optimal solutions as well as approximate solutions with guarantees.

Regarding the optimal time-bounded control in a simple subclass of linear hybrid systems, which consists of one continuous variable and global constraints. Each state has a continuous cost attached to it, which is linear in the sojourn time, while a discrete cost is attached to each transition taken. We showed the corresponding decision problem to be NP-complete and developed an FPTAS for finding an approximate solution. We implemented a small prototype to compare the performance of these approximate and precise algorithms for this problem. Our results indicated that the proposed approximation schemes scale. Furthermore, we showed that the same problem with infinite time horizon is in LOGSPACE.

We also studied optimal time-bounded control in multimode systems with discrete costs. We showed that an optimal control for this model can be computed in NExpTime and approximated in PSpace. We also showed that the one-dimensional case is simpler: although the problem is NP-complete (and in LogSpace for an infinite time horizon), we developed an FPTAS for finding an approximate solution.

Current research

A. Image compression based on a variable size multiple blocks SVD and genetic algorithm.

We present image compression technique using the Singular Value Decomposition (SVD) that factorizes any matrix A with dimension $m \times n$ into three other matrices U, S and V where $A = USV^T$ where U and V are orthonormal matrices of dimensions $m \times n$ and $n \times n$, respectively. I apply the SVD using three different approaches. The first approach is to apply SVD directly over the whole image and get the compressed images while the second is to split the image into sub-images that are equal in the dimensions and apply the SVD over every part independently to create the overall compressed image by concatenating the compressed output parts. The last approach we still split the image into sub-images using genetic algorithm which selects the number of sub-images as well as the dimensions of every sub-image based on the image texture.

B. Building trust and reputation on blockchain.

The main idea is to use the blockchain infrastructure to flood assessment questionnaires to the cloud providers as well as the cloud consumers and extract their opinions using artificial intelligence techniques. The extracted opinions affect the digital trust values for the services offered over the cloud based on a categorization schema for them. All the processes should be run without a third party to ensure the trust of the overall process by implementing it in the form of a smart contract deployed on the blockchain network.

C. Designing, implementing and manufacturing ADCS for cubic satellites.

Zagazig university in joint with the Egyptian Space Agency are cooperating to design, implement and manufacture a 2-unit cubic satellite for educational purposes. I am the team leader of a group responsible for designing and implementing the Attitude Determination and Control System. The challenge is to design the electronic printed board and implement the drivers and the protocols to communicate with the other sub-systems like the onboard computer. We also interested in designing the control strategies as well as selecting the control parameters to control and stabilize the satellite in all the modes.

Future work:

Nowadays, cameras –even the mobile ones– have very high resolutions. As we always say "a picture is better than a thousand word", people prefer sending photos and emotions rather than writing a letter or sending a message. So, I am interested in working in the problem of multi-label classification for indoor/outdoor photos. The overall aim of this problem is to understand the content of the images and classify every single image into multiple classes or labels.