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Case Study

Applications of Artificial Intelligence for Analysis of Floaters, Cataracts, Cells of Non-Responsive Retina: A Proposal

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Abstract

The following paper presents a pantheon of proposed solutions to eye problems using a hybrid combination of Ophthalmological [1] sciences along with engineering technologies like swarm intelligence, robotics, artificial and convolutional neural networks. In this paper we claim that these must provide optimal and more accurate results than recorded in our present statistics. This would be particularly helpful when surgery has risks. Human retina has in general the following five problems: 1. Floaters, 2. Macular degeneration, 3. Diabetic Eye disease, 4. Retinal Detachment, 5. Retinitis Pigmentosa. Cases where retina has been operated several times in the past are typical examples when we want to fix problems without a surgery. One may claim that internal medications can fix such problems. But here also we have problems like malfunctioning of optic nerve, disbalance in concentrations of different pigments of cone cells and so on. Also somatic cells like that of aqueous or vitreous humours may also be affected permanently and for the worse. As such, we need machinery to assist and/or improve signals as perceived by the eye (Ex: artificial ciliary muscles to automate the flexible bi-convex lens in eye). Every claim, hence in our paper, is a proposed mathematical model with a view to improve/add new innovations to existing clinical machines. As an example, we can use deep learning (CNN) [2] to extrapolate incomplete images perceived by a diseased retina to complete the image, convert combination of pixels into its corresponding adjustable feedable analog output which with proper amplification would be fed to cerebrum. Such innovations if implemented, not only helps us in curing patients who incurred such diseases in their lifetime but also would be an ever-lasting solution to those who genetically inherited them during their birth.

Keywords: *Floaters [3]; Cataracts [4]; Glaucoma [5]; Analog [6]; Retina [7]; Optics [8]; Artificial Intelligence [9]; Pixels [10]; Deep Learning [11]; Swarm [12]; Genetic Algorithms [13]; Heuristic [14]; Extrapolation [15]; Image Processing [16]*

Introduction

A cell is the structural and functional unit of any living system, be it unicellular or multi-cellular and same is applicable to the Human Eye. An exact mathematical analogy of a cell is that of a particle for a swarm. As an example, every cell of the human retina can be thought of as a particle where swarm obviously means the retina as a whole. Our Idea is to model every independent tissue or nerve (or any biological body) as some mathematical entity upon which we can perform our operations. But, let us understand first how technologies like Deep Learning, Computer Vision, Image Processing can help clinical surgeries or at least improve upon internal medications as applied to the eye. Through Computer Vision or Image Processing, we can identify different components of an image and perform predictions as necessary. Artificial Intelligence is a domain in Computer Science used to develop intelligent behavior in systems and solve real world

problems or emulate human behavior, in the very true sense. If we can provide cent percent remedy for our eye problems through only use of surgeries, drugs and medical sciences, then we are done. Else we look up for assisting machinery which would directly or indirectly help to improve "quality" of perceived image. Laser eye surgery was introduced in UK in 1990 and currently there are nearly 40 million variations of the same and more than 120,000 citizens opting for the same every year. The claim, therefore is, that we can improve the vision of these 10 percent of people who achieve 20/20. So we understand the need for using engineering sciences from one perspective. However, there is another major reason for motivation of our purpose. Some of the problems of abnormal perception of image by the eye are genetic in nature. Considering the Darwinian [17] theory to be true, we can argue that if a series of linear generations use our machinery along with medications, there is a possibility that a generation springs having very less error in their vision. Presently, we have more than 350 eye diseases like retinoblastoma, glaucoma, amaurosis and the list continues. So, we have a huge future prospect in this area of research.

Diagrammatic mapping

So, starting off we model every tissue into its corresponding mathematical analog, just as we discussed earlier. Look at the block diagram below:

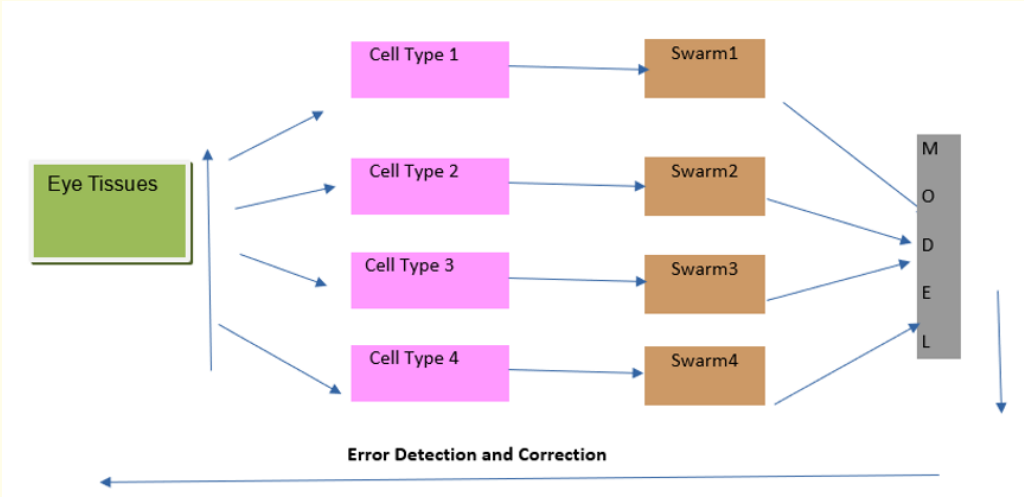

Figure 1: *Overall methodology in Block diagram.*

Our overall methodology in brief, will be as follows. First, we consider a segment of human eye tissue upon which we will apply our technique. Then using image-processing at microscopic level we identify different components of the given tissue. We model every single tissue independently into its corresponding swarm model. Treating every swarm particle (cell) we identify the nature of a particle's abnormal behavior and apply our medication.

Case Study

Case 1 (e.g. Cataract): When problem does not involve image perceived (all external or near about aqueous humour)

Now let us understand it in details. For this purpose let us consider the example of retina. On a broad basis the conjunctiva has in it two different types of cells: Goblet cells and Squamous Cells. Now we will model the earlier two different type of tissues into their corresponding swarm. Now, modern ophthalmological databases provide us essential data regarding the behaviour of the cells. Hence, before beginning the experiment we have to study the nature and condition of a cell in a swarm post-reactive behaviour to a chemical. We have to store their images in a database and with each we associate a binary number. So, now we have the swarm and we have to fix the prob-

lem (say, cataracts). Now to detect the cataracts in the conjunctiva we just have to inject our microscopic diagnostic (testing substance) and it will detect the floaters using image processing. Once image has been identified, the corresponding binary number can be retrieved and we have diagnosed the problem. Now, using PSO [18] we can find the area of maximum damage and we can apply our medication procedure. For this, inject the medicine into the nanomite which will travel to all areas for that swarm and transform that swarm into another swarm. This process is repeated heuristically with a safety limit (to be found out experimentally) until that swarm is optimised. In other words particles have such a structure that they cannot be optimised any further. So, one swarm is heuristically repaired. Now repeating this process for all the swarms we get our desired result. However, we have to keep in mind that once "i" out of "n" swarms for a tissue is optimised, we have to optimise the "i+1" swarm in such way that no previous swarm is hampered. Now, there is an important question here that is: what essentially do we mean by a medicine (as applied here)? Medicine here means an AI nanomite which can transform or improve the health of a diseased cell of a swarm into its healthy state by some minimum percentage (Again to be obtained experimentally!). Now, to simplify calculations and easy understanding, we assume every cell of a single swarm has a single problem. Then we require one type of nanomite per diseased swarm. Another question that may arise is: how to obtain the relative damage rate for a swarm? Model every cell of that category into a swarm and give to it an arbitrary velocity and displacement. The position should somehow be made a measure of the damage encountered and then by running the algorithm we will eventually end up finding the global optima. Assuming global optima do not change too often, we will divide local optima in the neighborhood of a particle by the global optima to obtain the relative damage rate. The relative damage rate is then made understandable to the nanomite using artificial neural networks which when injected into that actual cell category works to that extent for every particular cell. For detecting whether it is a cataract or any other problem, we can use deep CNN.

Case 2 (Ex: floaters): When problem involves the perceived image (areas near the vitreous humour, axon endings and synapses of optic nerve)

Here the problem is associated with cells which actually capture the intersection point of the rays of light after they pass through the biconvex lens in eye. The collection of such intersection point actually makes up the entire image. So, we have to identify those areas of retina which have faulty nature in either of rods or cone cells. Once those patches in the retina is identified by our proposed mechanism then we can find the area external to the faulty area. Once this external area is identified, we can extrapolate the same and we can recover the image perceived by the faulty area. Suppose, a human being is seeing a car. But due to some problem in retina, he sees the wheels to be missing. We are given to solve this problem. What our algorithm will do in such a typical case? Our algorithm will be modelled inside some proper automaton which will detect the area (or patches of area, as the case maybe) of the image which is faulty. Then it will move onto the area external to the faulty area and make sure it is perfect (this is done heuristically, see "Mathematical Modeling"). Once done, it will extrapolate the perfect image to get the complete image. Iteratively it will repeat the entire process for every faulty patch. Once we identify that we have reached the global optima we will stop.

Mathematical modelling

In this section we will try to put our equations in the most ordered fashion and try to put forward a mathematical model of the above literature.

$$\oint_{k=1}^{k=n} C(k)\{\int_{i=1}^{i=n} P(i)dp(i)\}dk = \sum_{t=1}^{t=n} Tissue\ G(t) \ldots\ldots\ldots\ldots\ldots (1)$$

The above equation represents modelling of all cells C(k) of a tissue type G(r) where t = r. Also P(i) represents the i^{th} property of C(k). Integration of all P(i) for a cell C(k) makes up the cell C(k). Integration of all C(k) makes up the tissue G(t).

$$\mu(p(r)) = \alpha * \frac{ActualImage(I) - ObserevedImage(I)}{ActualImage(I)} \ldots\ldots\ldots (2)$$

Here I is some combinations of pixels best fitted under a rectangle of fixed size (to be obtained experimentally) that is passed into the functions. Actual Image () is a function that returns a measured correctness of the actual image which we have to capture through camera. Observed Image (I) is the image observed and measured by the chemical fitted inside the nanomite. μ(p(r)) is to be obtained experimentally. is like the heuristic function but in this case it can be said to be the fitness () function. This function will help us to calculate how the swarm elements should rearrange themselves and in particular, calculate displacement and velocity vector for an optimum position.

Refer to the Methodology section of the paper. For Case 2 in section 5, equations (4) and (5) are valid. For Case 1, all the equations from 4-8 (both inclusive) are valid.

For every C(i) where i = 1 to i = n, do the following. Calculate P(i) where i = 1 to i = n, Calculate Max(c(i)).

$$\sum_{i=1}^{i=n} P(C(i)) = MAX\ (\mathrm{C(i)}) \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The above equation is used to replace every behavior of a cell by the best behavior of a cell for that property. By best behavior, we mean such a system of moves which directly or indirectly enhances the quality of perceived image. This equation is applied to every cell (better to say particle) of the tissue(swarm).

$$\delta\ P(i,j) \equiv\ Image\ [P(i,j)\ *(X(i),Y(i),X(j),Y(j))] \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

This function δ P(i,j) is used to find out the best fitting rectangle in terms of for an Image I. To determine what is percentage with which the image is faulty, we use the following equation:

$$\sum_{k=1}^{k=n} A(k)\ = \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} \mu(p(r))*\mathrm{P} \ldots\ldots\ldots\ldots(5)$$

The above equation uses the equation 2 as a derivative to complete its purpose. μ(p(r)) acts like a ratio in this case. Now our task is sort [19] A(k).

$$\oint_{r=1}^{r=n} A(k) = EXTRAPOLATE(A(k)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Equation 6 is the equation of termination. To fulfill this we have to find the external area as well. For this purpose, we have to choose r such that X(r+j), Y(r+j), X(i-r), Y(i-r) so that most accurate prediction can be made. Also, we cannot choose a huge value for "r" because it will increase the time and space complexities of the machinery. Mathematically we calculate r using a genetic algorithm using the following fitness function.

$$\frac{\delta\ P(r+i,r+j)}{\delta\ P(i,j)} < 1 \ldots\ldots\ldots\ldots\ldots(7)$$

$$Deep\ CNN(X(i+r,j+r)) \simeq CompleteImage(X(i+r),Y(j+r)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

The above equation completes the entire procedure.

Future Prospects

Here we will mainly discuss the future scopes and improvements of this research. This paper proposes the methodology but to apply it into practice we have to build the nanomite upon which the chemical substance (medicine) will be loaded. Also we have to make sure that after applying this repeatedly to all the generations of people who are under the same family, the probability that the next generation would incur the disease during birth should decrease. Also after curing a patient, we can use augmented reality [20] or virtual reality to

make their experience even more wonderful. Also because this technique is based on AI, we can use this core concept of this disease in curing cancer, AIDS because all of them originate from a single cell and we can control the behavior of cells. So the first next step should be to build this nanomite, the drug and we expect to share a much detailed paper on this nanomite in the near future.

Conclusion

Our keen motto behind writing this paper was to focus on the issue that we should combine engineering sciences in our clinical treatments. We must understand that we should try to find a different approach in solving problems like Cancer, AIDS or Diabetes because modern clinical machines are still in a challenge to solve such problems and we should focus on solving them from the very root. Chemotherapy in the case of Cancer or immunity drugs in case of AIDS only subdue the effect of the disease and extend the life of the patient but they do not guarantee complete cure from the very root. This should motivate and fire us to bring in better and most accurate technologies and fight to bring light to the faces of the millions.

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