# An Intelligent Nanorobotics System for Prevention & Monitoring of Blood Related Diseases in Precision Medicine with Artificial Intelligence

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*Abstract*—Currently the application of artificial intelligence for nanorobotics gains significant attention worldwide. The effective convergence of this technique helps in earlier diagnosis and treatment of various harmful diseases. Deep vein thrombosis also called as blood clot is a serious healthcare concern among humans that impacts several individuals every year. On the other hand, there are many numbers of researches that attempt to prevent the harmful impacts of the blood coagulation in human. In this regard, the proposed approach makes an effective convergence of the artificial intelligence and nanorobotic technology to provide an efficient solution for earlier detection of blood clot in humans. The major contributions are divided into twofold. First, we define an efficient nanorobot and artificial intelligence assisted framework for earlier blood clot detection. And the next, an efficient self-supervised learning model is proposed for the control of nanorobots. The simulation results of the proposed approach is found to be comparatively better than the conventional approaches.

***Keywords—nanorobots, hematology, self-supervised learning, blood clot, and precision medicine***

## I. Introduction

In today's world nanorobots remains to be a promising technology that bring in unprecedented opportunities for the healthcare applications. Usually, nanorobots are in size of 1 to 100 nanometres and they are inserted across the human body to perform various operations [1]. Often, over the decades researchers are actively involved in development of more tiny robots that could traverse across the human body, deliver drug with more precision, detecting diseases and preventing it as early as possible. Thanks to the advent of artificial intelligence technologies, that made the application of nanorobot feasible across a broad field of healthcare applications ranging from kidney stone detection to prevention of deep vein thrombosis and blood clot prevention across the human body [2].

While nanotechnology posses the huge potential to prevent the more deadly diseases such as deep vein thrombosis and cancer, Artificial Intelligence when converged with nanorobots has huge potential and it effectively bridges the gap between existing healthcare advancements and emerging technologies [3]. The operative use of artificial intelligence algorithms assists in processing the crucial information's associated to human body to make it effectively act within the human body. Practically, there are plenty of ways in which the artificial intelligence technique can impact the performance of the nanorobots [4]. The real challenge that comes here is that the concept of artificial intelligence for nanorobots may look clear but its real time implementation is highly tricky and has several complications [5].

Accuracy plays a vital role when it comes to nanorobotics application in healthcare. This is because the complex environment associated with nanorobot implementation makes it more challenging and often difficult to be processed in real-time [6]. Consequently, the data acquired from nanorobots holds a special significance in healthcare implementation. As every patient is unique, the effective convergence of these two techniques takes the precision medicine to a greater level of advancements [7].


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A more advanced research on nanorobots sounds more interesting, more specifically with the convergence of artificial intelligence techniques. But its real-time implementation includes certain drawbacks, which includes, imbalanced control of robot replication, probability of introducing toxicity across human body, loss of control of nanorobots across the human body, higher dependence of computer systems and difficulty in manufacturing [8,9]. Irrespective to the disadvantages, nanorobots has more significant applications when it is used appropriately [10]. In this regard, the proposed approach implements nanorobots with self-supervised learning approach for haematology. The key objective is to design an efficient nanorobotics system with self-supervised artificial intelligence algorithm for earlier blood clot detection and removal across the human body.

The organization of the paper is given as follows: Section 1 provides the introduction. Related works are described in section 2. Brief description to proposed work is given in section 3. Results are discussed in section 4 and section 5 concludes the proposed approach.

## II. Related works

This section provides a brief summary on works that are related to the proposed approach. The major contributions that are related to the nanorobots and the evaluation self-supervised learning models are analysed and summarised in an appropriate manner.

In [11] the authors Fernando et.al highlights the importance and significance of nanorobots in medicine. The authors make a brief analysis on medical micro and nanorobots. It is found through the study that the application of nanorobots in medicine still face technical, regulatory, and marketing challenges.

In [12] the author applies the ultrasound imaging techniques to the motion and control of the nanorobots. It provides a great potential of nanorobots in 2D and 3D space. However, the effective navigation of the nanorobots under various circumstances remains to be the difficult process.

In [13] the authors mainly focus on the motion and control of the nanorobots inside the human body. The authors have developed a kinetic model of the nanorobots with matlab and the performance measure of nanorobots are examined using various parameters. The adaptive control algorithm is used for the motion and control of the nanorobots.

In [14] the authors present the autonomous DNA nanorobots for efficient drug delivery systems. The nucleolin component associated with this system act as a molecular trigger for mechanical functioning of the DNA nanorobot.

In [15] the significance of self-supervised learning in applications with limited dataset is provided in detail. This approach applies self-supervised learning algorithm for medical image classification obtained from X-rays. Here, the focus is on multi-class classification. An innovative model named multi-instance contrastive learning is used for the classification of medical images.

A label-efficient classification method using self-supervised learning is given in [16]. The objective here is to apply self-supervised learning model for dental carrier classification. The classification performance is improved through fine-tuning of labels. The sensitivity and performance of the system is improved effectively.

In [17] the authors intend to improve the performance of image classification. Here, the model is derived using both the self-supervised and semi-supervised methods. The results of this approach are found to be comparatively better than the existing approaches.

A self-trained learning model for ensemble transformation is given in [18]. They are mainly used across the cases where the requirement for datasets is high and there is a scarce of labelled data. The method proposed in this paper improves the performance measures with consistency and improved confidence measures.

An effective model of self supervised learning for kernel dependent maximization is given in [19]. This work provides a new way of understanding towards the complex unlabelled datasets with minimal value of kernelized variance. This approach helps in optimization of the classification measures significantly resulting in improved performance measures.

An adversarial model for self-supervised contrastive learning is given in [20]. The prime focus here is on effective generation of adversarial data to detect the incorrect predictions. This approach is evaluated against the robust contrastive learning algorithms and the results are found to be comparatively better in comparison to traditional methods. More specifically, this approach provides impressive results when compared to transfer learning algorithms.

It is observed from the literature [21,22,23,24,25] that the nanorobots plays a vital role in healthcare applications and it has a significant scope from a future perspective. On the other hand, there are only a few literatures available that focus on the appropriate application of nanorobots in healthcare with significance to haematology. Further, the accuracy of functioning of human robots is crucial, otherwise it may lead to harmful effects. In this regard a more advanced approach is required in terms of the control and navigation of nanorobots specially with healthcare systems. Also, the data available to control nanorobots are highly limited. Hence, this work proposes a self-supervised learning model for the effective control and management of nanorobots. The detailed implementation is discussed in the forthcoming sections.

## III. Proposed Model of Nanorobotics System for Prevention and Monitoring of Blood Related Disease in Precision Medicine

Currently in the present scenario, nanorobots influence our daily lives in a many numbers of ways. Further, its application in haematology has grown significantly in an unimaginable manner. This is due to the reason that the nanorobots can respond more quickly and it helps to predict and kill diseases in a more efficient way. The major contributions of the proposed research is divided in two fold. First, we define an efficient architecture for the detection and removal of blood clots using nanorobots. Second, we present an self-supervised deep learning model for the effective control and navigation of the nanorobots in blood stream.

### *A. Materials and Methods for Nanorobots*

In general, nanorobots are efficiently defined to perform n number of tasks continuously in a nano scale dimension. Their major objective is to enable precision interaction with the nano scale objects. The main element used in the design of the proposed nanorobot system is carbon and its used as it contains the property of strength and chemical inertia. They are self-replicative and it works at the cellular, atomic, and molecular level to perform specified tasks. This is made with the help of acoustic signals and sound waves. Here, in the proposed method we adopt nucleic acid assisted nanorobots to construct a molecular machine from DNA. 3D nanomechanical devices and materials are assembled in a DNA structure to predict the blood clots. The activation of the nanorobots is made through small molecules of DNA, proteins and other molecules. Here, we make use of self-winding technology to build the nanorobots. This technology deposits multiple layers of numerous materials and they are made using the strain difference of the same material. At the moment of action of stress, the self-coiling structure of the nanorobot is spontaneously coiled into a spiral or the tubular structure. From a safety and health perspective of the patients the self-coiling material of the nanorobots are constructed using the organic compounds such as C, pd, Fe, Ag, etc. The proposed model of nanorobots are mainly based on biological propulsion that contains the combination of active microorganisms and human materials.

### *B. Proposed Architecture of Inteligently Guided Nanorobots for Effective Detection of Blood Clots*

The systematic view of the proposed architecture of the nanorobotic system is clearly illustrated in figure 2. The major components of the proposed nanorobotic system includes a nanocapacitor, swimming tail, exhaust motor, opening and closing barriers, nano lenses, and payload. Nano capacitor acts as a power source that provides efficient supply of energy resources for the functioning and operation of the nano devices. Swimming tails and fins are mainly used for the traversal and navigation of the nanorobots across the human body. They are mainly associated with effective navigation of the nanorobots throughout the human body. Payload carried the small portion of the medicine to dissolve the blood clots present inside the human body. Nano lenses are mainly used to detect and destroy the harmful blood clots detected in the human body with the usage of the medicine carried at the payload. Exhaust motors are mainly used to collect the waste that are acquired as a result of destroying the blood clot. Whereas the lids open and close after every blood clot is dissolved and it assists in safer disposal of wastes.

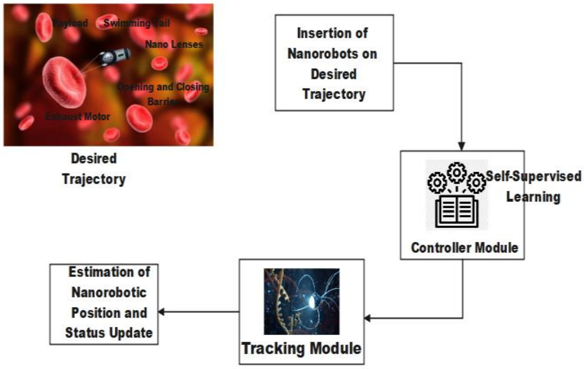


Fig. 2. Proposed Model of Nanorobot Architecture with Self-supervised AI Model for Blood Clot Detection and Recovery

First the nanorobots are inserted in to the desired trajectory across the human body. Once the nanorobots are inserted in to the human body the control is passed to the controller module. The proposed model of self-supervised algorithm is implemented in the controller module for the effective propulsion of nanorobots across the human body. It includes the effective navigation of the coils and the particles. Then with the help of the semi-supervised learning-based GAN model the proposed approach tracks the presence of blood clot position in the tracking module and dissolve it effectively with the medicine carried out by the payload system.

*C. Proposed Approach of Self-Supervised Learning Model for the Effective Control and Tracking of Nanorobots to Dissolve Blood Clots*

1. Progressive Augmentation of GAN:

The key idea behind GAN technology is to establish a competitive training between two players. They are generally termed on generator and terminator. Initially the discriminator differentiate the samples a $\epsilon A$ . From data distribution, here, the generative mode and distribution is defined as Ug. Whereas the binary classification is represented as $C:A_l \rightarrow [0,1]^2$ .

Now the generator challenges the discriminator by making the synthetic samples in to data samples. Here, in the proposed method, A denotes compact metric space such as image space [-1,1] dimension. Such that U(g )and $U_d$ ϵ A . The model distribution is defined by the function F that maps a random vector r ~Ur towards the synthetic data sample. Which is defined as ag = F(r) ϵ A.

This in turn is formulated as, min F and max C

$$\mathrm{E}\, U_d \{\log[C\,(a)]\,\} + \mathrm{E}\, U_g \{\log[\,1 - e(a)]\,\}$$

Let us consider r ϵ {0,1} that represent a random bit with uniform distribution

$$(r) = \frac{\delta\,(r) + \delta\,(r-1)}{2}.$$

In association of r with a. The joint distribution (r,a) is compared as,

$U_{r,a}$ (r,a) Δ $\frac{Uc(a)\ \delta(r)+U_{\delta}(a)\delta(r-1)}{2}$

$P_{r,a}$ (r,a) Δ $\frac{Ug(a)\ \delta(r)+U_{c}\ (a)\delta(r-1)}{2}$

Which, the divergence is equivalent to,

$C_{yr}(u_{a,r}$ ll $P_{a,r}) = C_{Jr}(u_c$ll $u_f)$

At every level at progressive argument D . The dimensionality of r can be enhanced from 1 to D , r= { $r_1, r_2, \ldots\ldots r_D$ } . The complexity at task related to the discriminator is increased with the length 'r' grows.

In consideration of the previous equations as starting point and with r, being the succession. The recursive function to construct the paired joint distribution of (a,$r_1$).

$$Q_{a,r_1}(a,r_1)\ \Delta\ Q_{a,r_d-1}(a,r_d-1)$$

$$\frac{\delta[r_1]}{2}+ P_{a,rd-1}(a,r_d-1)\ \frac{\delta\,[r_d]}{2}$$

$$P_{a,r_d}(a,r_d)\ \Delta\ P_{a,r_{d-1}}\,(a,r_{d-1})\ \delta\ (r_d)/2\quad+\quad Q_{a,r_{d-1}}(a,r_{d-1})\delta(r_{d-1})/2$$

This result is divergence equalities at

$$C_{JR}\,(U_d \text{ ll } U_J) = C_{JR}(U_{a,r1} \text{ ll } P_{a,r1}) = C_{JR}(U_{a},r_D \text{ ll } P_a ,r_D ).$$

The min-max optimization associated with GAN is given as min F and Max C

$$E_{u_a,r_d}\{\log[c(a,r_d)]\}\quad\forall\quad E_{Pa.sd}\{\log[1-c(a,r_d)]\}\quad\forall\ \in\{1,2,3,\ldots D\}$$

$U_{a,r_d}$ and $P_{a,r_d}$ are the two joint distributions and the function C pinpoint (a,$r_d$) ∈ A $[0,1]^d \rightarrow [0,1]$. The optimal value of c $f_q$ a sized F is given as

$$C^*\ (a,r_d) = \frac{U_{a,r_d}(a,r_d)}{U_{a,r_d}(a,r_d)+P_{a,r_d}(a,r_d)} = \frac{U_c(a)}{U_c(a)+P_c(a)}$$

The inner maximum value obtained as equivalent to

$C_{JR}\ (U_{a,r_d}$ ll $P_{a,r_d}) = C_{JR}(U_c$ ll $U_f)$

For d=1,2,3.....D

With the increase in length d of r , the dimenstion of input associated with the discriminator grow significally. The above derived formulation for min-max optimization can be extended for any two random variables. It provides the sequence for any two random variables. It provides the sequences of ER divergence estimation process through auxiliary bit vector 'r' that is regularized for the process of generative adversarial n/w training. Initially, the number of data samples related to $r_d$ grows exponentially with d , thus preventing the problems over fitting to training set associated with discriminator consequently, the task associated with discriminator become harder with distance d.

The dimensionality value c increases and the label (a,$r_d$) is exchanged with random bit $r_d$ the decision boundary gets little complicated . Here, the value of d increases progressively to balance the gap between discriminator and generator, Whenever the discriminator becomes too strong and finally when the performance of the training model is started with aurgumental level, the process of addition as extra bit should be made to change the landscape of loss function and this process further increases the process of learning.

2. Self-Supervised Model:

The progressive GAN algorithm is trained over the unlabeled data associated with functioning of nanorobots and the authentic samples for self-supervised learning is acquired in an appropriate manner. In the next step, the encoder is trained over the augmented data that includes both the minimal amount of labeled images and the generated samples of program.

Variational Auto Encoders:

This section deals with the process of construction and training of variation auto encoder. The major thing that has to be taken in consideration is the architecture of encoder and decoder. Here, we consider both VAN with fully connected layer as well as the VAE with convolutional layer. VAE with fully connected layer is called as dense. The encoder possess one or more hidden layers connecting the sampled n value to opposite layer.

The proposed work considers symmetric VAE, That means the dimensions associated with the hidden layers are similar to that of the encoder. But in a reverse order rectified linear unit (RELUs) is used for the activation of hidden units. Sigmoid function is used to retrieve the grayscale pixels. The next important thing to be considered to define fully dense VAE. This assist in selecting the dimensions of hidden layers of encoder.

The proposed method incorporates convolution layer as it deals with the unlabelled data. This is because models with convolution auto encodes is called as convolutional VAE. Thus the encodes includes one or more convolutional layer, continued by one or more dense layers. This all together establish the input layer to ($\delta, \log \mu$ layers). Decoder includes one or more dense layers, preceded by deconvolutional layers. This connects the sample n value to the opposite layers. Here, symmetrical architect is only considered for the dense hidden layers. For every deconvolutional layer the parameters such as kernel size, number of filters, types of padding and stride should be specified ReLVs is used for the activation of hidden units and the sigmoid function is used to compute the grayscale pixel values between and for the opposite units. The effective implementation of VAE access in acquiring the lateen space representation of the unlabelled data.

Multi-Layer Perceptron:

A batch of instances from the latent data is randomly selected to train the classification model. One or more fully connected layer along with multilayer perception is selection to prevent oversitting. The soft max is the final layer with considerable number of opposite classes. This layer is trained with a fixed number of epochs uncertainly sampling

One common problem with reconstruction error or uncertainly sampling is outliers , In order to overcome this issue it is necessary to compute the representative measure and this value should remain between 0 and 1 for maintaining consistency . Bad representative is given by 0 and the good representativeness is

Indicated as 1: In the context of the proposed VAE architecture, repetitiveness is expressed by means of average similarities of the data instance to all other data in the pool $\sigma$ .

$$\text{rep(p)} = \frac{1}{l\sigma l p_u \epsilon \sigma} \sum sim\ (P, Pu)$$

Let us consider that we have two images p and q of M Pixels each, with pixel intensities ($P_1, P_2, \ldots.. P_m$) and ($q_1, q_2, \ldots. q_m$) with ( $0 \leq P$ , $q \leq 1$ ). Then the similarities between the two images assured to between 0 and 1 . This is because the pixel intensities are non negative. The distance measures d(p,q) can be used to show the represented as

$$\text{rep(p)}=1 - \frac{1}{l_{max}\ l\sigma l p_{u\,\epsilon\,\sigma}} \sum_{p_{u\,\epsilon\,\sigma}} l(p, p_u)$$

Here, $l_{max}$ represents the upper body of the distance measure or else the maximum identified average distance for the given data (if such a bound does not exists).

This provides the measure between 0 and 1. This value can be easily converted into the similarity measure by considering

Sin (p,q) = 1-$l$ $(p, q)$

In this way, the values are transformed to find the similarity measure.

## IV. Results and discussions

This section clearly illustrates the results and discussions associated with the proposed model of research. Conceptually, the design of nanorobots is crucial for the effective analysis of this research. However, in real-time construction of nanorobots is a tedious process and it is even a complete stream of research area. For the purpose of reliability, a similar pattern of nanorobot is purchased and it has been modified with certain changes to construct the model of working prototype. The experiment relies purely on the developed model of prototype. For a better accuracy, the self-supervised model is simulated separately to test is reliability measures. In both the cases, the results are found to be satisfactory and the results are discussed in detail.

The experiment is mainly based on the appropriate selection of nanorobot for research, effective design of nanomaterials and apparatus for the scaled model of system and the anatomy of bloodstream. The apparatus for simulation includes the insertion of nanorobots with the fluid constructed using the PVC. This setup is closely similar to the human body and it enables easier observation of the nanorobots and its traversal throughout the fluid. The pipe elements are sized correctly based on the size of the nanorobots. Initially, the model is tested for debugging and errors and later it is evaluated for its performance. The nanorobots are made to traverse through the freely suspended liquid and particle filled liquid to mimic the various kinds of blood conditions. Under various conditions the robots are tested effectively and the results are analysed.

The results of the experiment is mainly assessed based on the four factors such as flow, viscosity, flow particles, and flow rates. The flow rates are numerically quantified to 0 and 1. The response of the experiment is measure in terms of speed in seconds and the results are clearly illustrated in table 1.

TABLE I. Comparative Results of the proposed approach

| Standard | F1 | F2 | F3 | F4 | Block | Algorithmic Speed/ Response (sec) |
|---|---|---|---|---|---|---|
| 45 | 124 | 0 | 0 | 1 | 1 | 2.5 |
| 49 | 517 | 0 | 0 | 1 | 1 | 0.7778 |
| 75 | 125 | 1 | 1 | 1 | 1 | 1.856 |
| 27 | 515 | 0 | 0 | 1 | 1 | 0.6675 |
| 70 | 516 | 0 | 1 | 0 | 1 | 0.4321 |
| 40 | 516 | 1 | 1 | 0 | 1 | 0.4125 |
| 68 | 517 | 0 | 1 | 1 | 1 | 0.433 |

In table 1, factor 1 represent the viscosity measure of the fluid and its measured in units cP, factor 2 is associated with blood flow, factor 3 defines particles, and factor is associated with the flow rate. The observation made through the partial prototyping model shows the proposed model of intelligent robotic system provides better response in terms of speed and response in seconds. The major observation made through the experiment is viscosity is the one major factor that greatly influence the results of the experiment. The presence of particles and no particles do not make much difference to the system but it greatly assists in effective detection and anticoagulation of the blood clots. Further, the complete plot graph of the response of the model is briefly illustrated in figure 3.

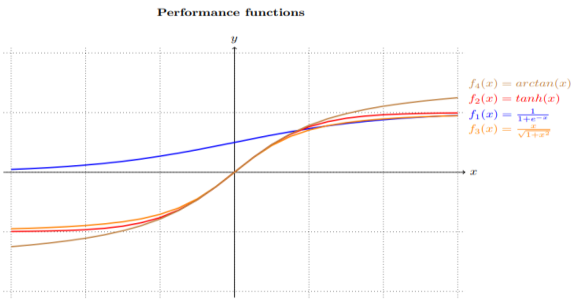


Fig. 3. Plot of Proposed Self-Supervised Learning Model in terms of Performance

The significance of the proposed approach is plotted in terms of graphs and it is depicted. The results are found to be satisfactory and the above chart confirms the significance of the system.

## V. CONCLUSION

Nanorobots are pioneering the healthcare sector with numerous improvements and innovative diagnosis and treatment measures. When it comes to hematology its application plays a crucial role. With respect to the advances in nanorobots for healthcare applications it accuracy plays a vital criteria as the loss in control of nanorobotic function may result in harmful effects. In this regard, the proposed approach presents an intelligent nanorobotic system for effective monitoring and control of blood related diseases. More specifically in diagnosis and dissolvement of blood clots across human body in a efficient manner. We propose a novel self-supervised learning algorithm using GAN model for the effective control and management of nanorobots. There is many ongoing research work in this area to bring healthcare to the next level of advancement. But the major drawback here is that those approaches are mainly dependent on computer simulations and there exists no realistic dataset on how nanorobots works inside the human body. So this, work bridge this gap with the development of an efficient prototyping model. In future, this work could be extended with more detailed architecture of nanorobots with efficient deep learning models for control and management of nanodevices.

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