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Swine Influenza Mimicked Optimization (SIMO)

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Abstract—In this paper, Swine Influenza Model based Optimization (SIMBO) is modified as Swine Influenza mimicked Optimization (SIMO) and explored through the application in the antenna design. Different researchers proposed different optimization techniques and algorithms so that the accuracy of optima will be improved. For fast convergence and better accuracy SIMBO with its variants such as treatment (SIMBOT), vaccination (SIMBOV) and quarantine (SIMBOQ). We have modified Swine Influenza model to propose new technique known as SIMO. In SIMO, health of individuals is improved by synchronizing vaccination, quarantine and treatment. Test 1 and Test 2 are used before vaccine and quarantine respectively to adjust antiviral dose dynamically during its treatment. The additional feature in SIMO such as infection factor control and improve the health of individuals gradually without checking the state/health at every day. SIMO changes solution indirectly during treatment and directly via vaccination and quarantine. The time varying treatment control the health of individuals in defined days such that individual will not feel illness for longer duration. An available closed form formula of equilateral triangular microstrip patch antenna resonant frequency has been used to form the fitness function in order to optimize the dimensional parameters. The proposed technique is used to determine the accurate resonant frequency of equilateral triangular microstrip patch antenna of different dimension. In order to optimize the technique with speedy convergence and effective precision of global optima, this method also used for the optimization of standard benchmark functions.

Keywords: Equilateral triangular microstrip patch antenna, Quarantine, Swine flu, Swine Influenza Mimicked Optimization (SIMO), Swine Influenza Model based Optimization (SIMBO), Treatment, Vaccination

I. INTRODUCTION

Swine flu is caused by influenza viruses. The swine flu will spread quickly when person comes with contact of another person inflected by swine flu and affects many people. To limit spreading of swine flu, different mathematical models have been proposed [1-10]. Kermack and McKendrick developed first SIR (Susceptible-Infectious-Recovered) mathematical model to limit the spread of swine flu [2-6]. SIR model is modified by researchers by adding the concept of treatment, vaccination, quarantine and isolation etc [3]. The SIMBO is proposed in 2013 [11]. The SIMBO is based upon the mathematical models of swine flu i.e. Susceptible-Infectious-Recovered (SIR) [11]. SIMBO consist of three variants i.e. treatment (SIMBOT), vaccination (SIMBOV) and quarantine (SIMBOQ). SIMBO variants enhance convergence as well as accuracy during optimization of multimodal functions. The use of evolutionary optimization techniques has grown considerably over the past several years. In 1975, John Holland convinced Genetic Algorithm (GA) [12]. Genetic Algorithms are emerging tools to many real world applications of diverse nature. Self-adaptive search based PSO was proposed in 1995[13]. PSO is based upon birds flocking and fish schooling. The researches proposed new variants of PSO to improve optima quality and convergence [14-17].

The miniaturized antennas used in wireless communication technology day by day. To avoid adjacent channel interference, accurate resonant frequency of antenna is required in the present wireless scenario [18-24]. Rectangular Microstrip Patch Antenna widely used in wireless communications extremely compatible for embedded antennas and seems to be potential radiator for bio-medical applications [18-24]. Microstrip Patch Antennas use different types of shapes like circle, semi-circle, ring, triangle, square, rectangle, L, ellipse, star etc. The different shapes of antenna used for particular applications [18-24]. The standard expressions given in literatures used to calculate resonant frequency of RMSA [20-24].

The neural network, BFO and PSO used to determine accurate resonant frequency of Rectangular Microstrip Antenna antenna [18-24]. Similarly soft computing tools used for determination of resonant frequency of equilateral triangular microstrip patch [25-29]. The resonant frequency calculated by these expressions gives errors as compared with the experimental values.

In this paper, we have modified the Swine Influenza mathematical model to propose a new soft tool known as Swine Influenza Mimicked Optimization. The proposed technique is used for accurate determination of resonant frequency of equilateral triangular microstrip patch antenna of different dimension. This paper has four sections. The section 2 presents step by step development of proposed method. The Section 3 discusses the steps to calculate resonant frequency of equilateral triangular microstrip patch antenna and experimental results of the same are presented in this section only. The Section 4 concludes the paper.

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II. SWINE INFLUENZA MIMCKED OPTIMIZATION (SIMO) DEVELOPMENT

The objective for the development of new or hybrid optimization technique is balance between exploitation and exploration. Exploration results to wander the members in whole search space and exploitation results in improving accuracy of optima or refining the local search. So, based upon the previous solutions, the intelligent technique explores the new region to improve optima quality and speed up the convergence. The SIMO technique intelligently combines exploitation and exploration behaviors in the foraging process. The time varying parameters of the SIMO intelligently optimize the multimodal search landscapes efficiently and dimensionality.

By modifying the SIR models of swine flu [3], new technique SIMO is proposed in this paper. The process of protecting the individuals from swine flu such as treatment, vaccination and quarantine are incorporated in SIMO. Therefore, SIMO optimize any function by synchronizing vaccination, quarantine and treatment. The main objective of SIMO is to achieve good solution of complex functions with low cost. In this section, the development of SIMO is presented by following sections.

A. Terms used in Paper

Individual: Member.

Population: Group of Individual or Member

Susceptible (S): Susceptible Individual or Member

Infectious (I): Individual or Member infected by other virus or swine flu.

Recovered (R): The individual not infected by swine flu or other virus.

TM: Number of members in group. The initial population is assumed as susceptible. During and at the end of optimizations, individuals in population results in infectious and recovered cases as given in Eq. (1).

$$TM = \sum I + R \tag{1}$$

A confirmed case: Member in the group is infected.

Day (D): Generation/ Iteration

Total_ Day (TOD): Total iterations.

State(S): Health of individual.

Epidemic_State (ES): Individual best state.

Epidemic_Health (EH): Individual or personal best fitness

Panademic_State (PS): Healthy individual or global best state.

Panademic_Health (PH): Global best fitness.

Primary Symptoms of swine (H1N1): The primary symptoms considered in SIMO are explained below.

a. **Fever (Fe):** Body temperature

b. **Cough (Co):** Chronic cough.

c. **Fatigue and headache (FH):** Fatigue due to work and headache indicates pain in the head.

The summation of primary symptoms is considered as one as given in Eq. (2).

$$TotalPrimaryInflections = \sum Fe + Co + FH = 0.4 + 0.4 + 0.2 = 1 \tag{2}$$

Primary (Day): The time varying primary infections per day are given by Eq. (3). Total influence of primary symptoms is indicated by first term in Eq. (3) and primary infections are linearly decreases as the day progresses due to second term.

$$Primary(Day) = (Fe * Co * FH) * \exp(-CurrentDay / TI) \tag{3}$$

R0 = New infections. During SIMO simulations, the value of R0 is taken as 0.014.

Secondary infections Per Day (Secondary (Day)): The time varying secondary infections per day is developed is given by Eq. (4). It linearly decreases the secondary infections

$$Secondary(Day) = R0 * \exp(-CurrentDay / TI) \tag{4}$$

Swine flu Test: The health of member is checked by swine flu test to detect the member is infected by viral infections or swine flu. The test1 is used for vaccination and test 2 is used for quarantine.

Vaccination (V): The term vaccination refers to vaccine given to infected individual.

Vaccine (Vc): It is the amount of vaccine dose given to the inflected member depends upon secondary and primary infections as well as current day and is given in Eq. (5). It also linearly decreases with time.

$$Vc(Day) = [Secondary(Day) / Primary(Day)] / Day \tag{5}$$

Treatment (T): Antiviral drugs given to infectious/recovered individual to recover the health.

Quarantine (Q): The isolation of confirmed cases of swine flu from population.

α: Vaccination Probability

β : Quarantine Probability

μ: Recovered Probability

$$Total\ Probability = \sum \mu + \alpha / \beta = 0.2 + 0.8 = 1 \tag{6}$$

Infection Control (λ): It is used to restrict the treatment and health of individual without checking the health at every day.

B. Model of Swine Influenza Mimicked Optimization(SIMO)

The model of SIMO is given in Figure 1. It follows optimization through vaccination, quarantine and treatment. In SIMO, vaccination, quarantine and treatment are synchronized to improve the health of individual. Test 1 and Test 2 are used before vaccine and quarantine respectively to adjust antiviral dose dynamically. Due to one infected member in group leads to everyone in the group is susceptible. Each individual in the search space undergo for swine flu tests based upon probability. The swine flu test 1 is based upon the health of current individuals in the population. During vaccination, based up on the current health of individual, recovered individual health remains same and infected individual is treated with vaccine. After swine flu test 2, recovered individual is the part of population and confirm cases of swine flu are quarantine from population. The dynamic treatment given to all members in the population based upon secondary and primary infections as well as current state and ES. The treatment is based on probability. In presented technique, the state of infected/confirmed case is updated indirectly through treatment and directly through vaccination and quarantine. The six steps of SIMO are given below.

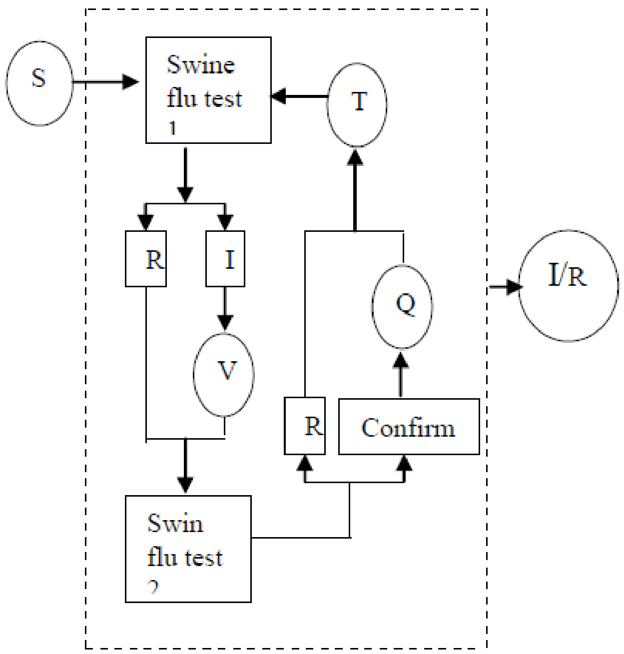

Fig. 1.Model of SIMO

C. Basic steps in SIMO

Step 1: Health Evaluation

Initially, fitness/ health of all members are evaluated based on cost function. As in hospitals, all the samples of individual are collected in each ward of hospitals. Each individual sample is collected and tested to check whether the individual is infected by any other virus or swine flu.

Step2: Swine flu test 1

Test 1 is used to test whether member is required vaccine or not and it depends on the threshold value. If current fitness of member is less than the dynamic threshold 1 (DT1) then it is it is a recovered case otherwise an infected case. Initially, members are sorted in ascending order based upon current health of each member in the population. The best 50% member's health is used to decide the threshold value of *DT1* as given in Eq. (7). The value of *DT1* changes dynamically during every day.

DT1= [Sum (Health (1: Sr))/Sr] (7)
For n=1: TM
If Health (n) < DT1

Recovered Case (R)
Else
Infected case (I)
End
End

Step 3: Vaccination

The spread of any disease can be controlled by vaccination. The vaccination is introduced into body to protect member against swine flu and inducing immunity [3]. The vaccine is given to infected case of swine flu. The amount of vaccine (Vc) depends upon current secondary and primary infections as well as current day. Due to vaccination, the state of infected individual is changed directly. The member is treated with vaccine, if α is larger than *random and current health* of member is larger than threshold 1 (*DT1*) otherwise, there is no change in the state of member. To change less number of member state directly, the vaccination probability (α) is kept high (0.8).

For n =1: TM
If random > α
If Health (n)> DT1
*S (n) =S (n)*Vc*
End
End
End

Step 4: Swine flu test 2

It is used to test individual is confirmed case of swine flu or not. If current health of member is less than dynamic threshold 2 (*DT2*) then individual is recovered case otherwise it is confirmed case. *DT2* is the average health of population at current day as given in Eq. (8). The value of *DT2* changes dynamically at every day.

DT2 = [Sum (Health (1: TM))/TM] (8)
For n=1: TM
If Health (n) < DT2

Recovered member
Else
Confirmed member
End
End

Step 5: Quarantine

Quarantine is used to isolate the infected member of swine flu such that other members will be prevented from swine flu. The quarantine used in two steps i.e. segregation and isolation. After swine flu test2, members are identified for segregation. The identified members inflected by swine flu are isolated/quarantine from the population. Due to quarantine of members, the population count will be change. Therefore to remain the population count constant, the quarantine cases are swapped with ES. To change the state of member suddenly or gradually, *random* is multiplied with ES. Members are quarantine, if β is greater than *random* and current health of member is greater than *DT2* otherwise members are not isolated from the population. To isolate less numbers of members from group, quarantine probability (β) is kept i.e. 0.8.

For n =1: TM
If random > β
If Health (n)> DT2
*S (n) = ES *random*
End
End
End

Step 6: Treatment

Treatment is often a trial-and-error process and based up on signs, symptoms and type of disease. Initially standard dose of antiviral drugs are given to the patient to improve the health. After first treatment, the health of individual is observed by doctors. If the health of member is not improved then dose is increased/decreased or previous dose is withdrawn and a new dose is administered.

In SIMO, the treatment is based upon secondary and primary symptoms as well as current and epidemic state. The time varying treatment improves health of individual as early as possible. The state of individuals updated by Eq. (9).

$$S(m+1) = S(m)*(\lambda-1)+\lambda*[\Pr imary(Day)*rand(1-ES(m)/S(m)) +Secondary(Day)*rand*(1.1-ES(m)/S(m))] \quad (9)$$

The infections factor (λ) control the health of individual gradually. The observations of primary and secondary symptoms are used for treatment as given in Eq. (9). If health of member is improved day by day or near to *ES* then no treatment is required for member. If μ is larger than *random* then treatment is given to the individuals otherwise it will continue with the previous state. The value of μ (0.2) is kept small to improve the health of most of members in the group.

For k=1: TM
If random > μ
Give treatment (Update S (m+1) as given in Eq. (9))
End
End

Pseudo Code of SIMO

Parameters Initializations

TM, TOD, Co, FH, Fe, R0, α, β, *μ*, *Sr* and λ

For Days = 1: TOD
For i = 1 : TM
Health (i) = Fitness Evaluation
End
Update Epidemic_State, Epidemic_Health , Panademic_State and Panademic_Health

$$\Pr imary(Day) = (Fe*Co*FH)*\exp(-CurrentDay/TI)$$

$$Secondary(Day) = R0*\exp(-CurrentDay/TI)$$

$$Vc(Day) = [Secondary(Day)/\Pr imary(Day)]/Day$$

Vaccination (Q)

Sort members in order of ascending health
DT1= [Sum (Health (1:Sr))/Sr]
For k=1: TM
If random > α
If Health (k)> DT1
*S (k) =S (k)*Vc*
End
End
End

Quarantine (Q)

DT2 = [Sum(Health (1:TM))/TM]
For n=1: TM
If random > β
If Health (n)> DT2
*S (n) = ES *random*
End
End
End

Treatment (T)

For m=1: TM
If random > μ

$$S(m+1) = S(m)*(\lambda-1)+\lambda*[\Pr imary(Day)*rand(1-ES(m)/S(m)) +Secondary(Day)*rand*(1.1-ES(m)/S(m))]$$

End
End
End

III. RESONANT FREQUENCY OF EQUILATERAL TRIANGULAR MICROSTRIP ANTENNA USING SIMO

Equilateral triangular microstrip patch (ETMP) antenna resonant frequency (*fr*) depends upon parameters like permittivity of the substrate (ε_r), triangular patch length (*a*) and height (*h*) of the substrate [25-27]. The geometric of equilateral triangular microstrip patch antenna shown in Figure 2.

SIMO has been used for accurate determination of resonant frequency of ETMP antenna in this section [25]. The results of SIMO are compared with experimental values, GA and PSO. The objective function of SIMO is mean squared error (MSE) which minimize the squared difference between the measured resonant frequency and the calculating resonant frequency for given Eq. (10) [28-29]

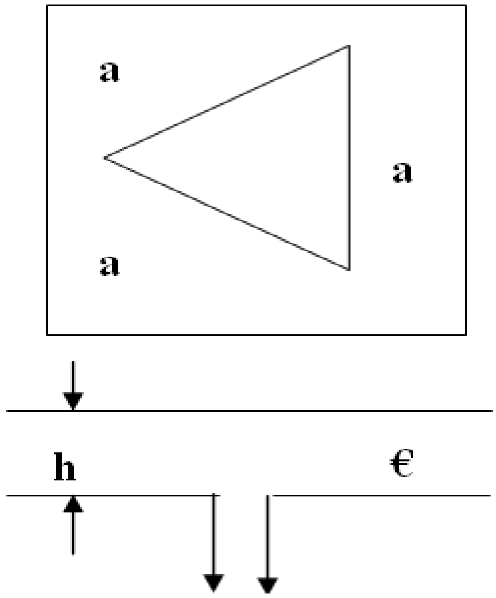

Fig. 2.Geometry of Equilateral Triangular Microstrip Patch Antenna

$$f_{m,n,l} = \frac{2C}{3a_{eff}(\varepsilon_r)^{\frac{1}{2}}}(m^2+mn+n^2)^{\frac{1}{2}} \quad (10)$$

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$$a_{eff} = a\left[1+\frac{2h}{\pi\varepsilon_r a}\left\{\ln\left(\frac{\pi a}{2h}\right)+1.7726\right\}\right]^{\frac{1}{2}} \qquad (11)$$

Where,

$f_{m,n,l}$ = resonant frequency,

C= Velocity of light in free space,

a = Physical length of the triangular patch,

a_{eff} = Effective length of the triangular patch,

h = Substrate thickness,

ε_r = Permittivity of the substrate.

The results of SIMO are compared with GA [28-29] and PSO [25]. The table 1 shows patch numbers, antenna parameter, measured resonant frequency, resonant frequency obtained by various techniques and difference between measured resonant frequency and obtained resonant frequency by various techniques. The difference or error between measured resonant frequency and resonant frequency by each of the technique for various patch numbers are shown in Figure 3. The patch numbers and resonant frequency obtained by various techniques are presented in Figure 4. As seen from Table 1, it is observed that the error is less than 0.0001% for SIMO.

Table- I: Result for Equilateral Microstrip Patch Antenna Elements

Patch No.	Mode	ε_r	a (cm)	h (cm)	Meas. f_r (GHz)	GA[28-29] f_r (GHz)	PSO[25] f_r (GHz)	SIMO f_r (GHz)	Diff. Meas. f_r &GA %	Diff. Meas. f_r &PSO %	Diff. Meas. f_r & SIMO %
1	TM_{10}	2.32	10.00	0.159	1.280*	1.281	1.2800	1.280	-0.0010	0.0000	0.0000
2	TM_{11}	2.32	10.00	0.159	2.242*	2.219	2.2421	2.242	0.0230	-0.0001	0.0000
3	TM_{20}	2.32	10.00	0.159	2.550*	2.562	2.5501	2.550	-0.0120	-0.0001	0.0000
4	TM_{21}	2.32	10.00	0.159	3.400*	3.389	3.4000	3.400	0.0110	0.0000	0.0000
5	TM_{30}	2.32	10.00	0.159	3.824*	3.843	3.8242	3.824	-0.0190	-0.0001	0.0000
6	TM_{10}	10.5	0.41	0.041	1.519^	1.501	1.5190	1.519	0.0180	0.0000	0.0000
7	TM_{11}	10.5	0.41	0.041	2.637^	2.601	2.6370	2.637	0.0360	0.0000	0.0000
8	TM_{20}	10.5	0.41	0.041	2.995^	3.003	2.9952	2.995	-0.0002	-0.0002	0.0000
9	TM_{21}	10.5	0.41	0.041	3.972^	3.972	3.9732	3.972	-0.0002	-0.0002	0.0000
10	TM_{30}	10.5	0.41	0.041	4.504^	4.504	4.4402	4.503	-0.0012	-0.0012	0.0001

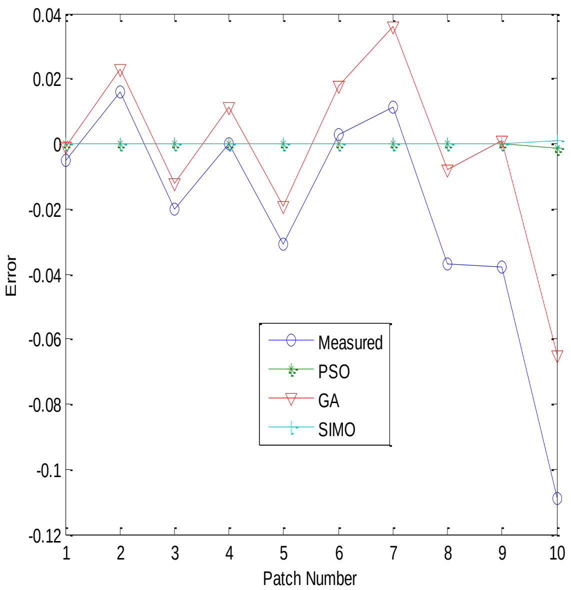

Fig. 3.Error between measured and obtained ResonantFrequency for various Patches

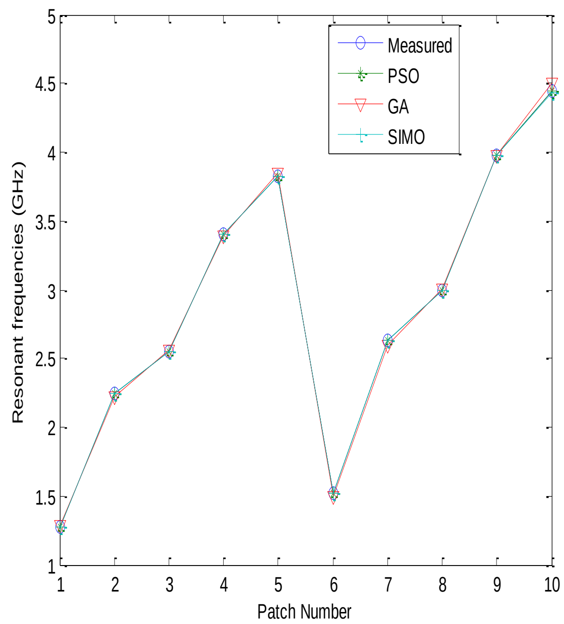

Fig. 4.Patch Number verses Resonant Frequency

IV. CONCLUSION

We have introduced modified evolutionary technique known as SIMO based upon SIR models of swine flu. We have modified the mathematical model of Swine Influenza. In SIMO, vaccination, quarantine and treatment are synchronized to improve the health of individual. Test 1 and Test 2 are used before vaccine and quarantine respectively to adjust antiviral dose dynamically during its foraging process. Dynamic treatment forces the SIMO algorithm to cope up with any type multimodal functions efficiently. The SIMO changes solution indirectly through treatment and directly via vaccination and quarantine. The vaccination and quarantine process improves the performance of SIMO because the confirmed cases are swapped with best member in the population and infected individual are treated with swine flu vaccine. The time varying treatment encourages the members in the population to wander in the entire search space. Due to this treatment individuals will not be trapped in local minima and it will avoid premature convergence. All the parameters in SIMO changes dynamically while primary symptoms and *R0* is kept constant. Due to high probability of vaccination/quarantine, member's health will improve directly. The low probability of treatment will allow recovering the health of most of individual in the population.

The proposed technique used to calculate the accurate resonant frequency of ETMP antenna of various dimensions. The results of the proposed technique are compared to GA and PSO. The results of SIMO are in good agreement thus encouraging the use of SIMO for antenna design for space and bio-medical applications. Further the proposed optimization technique can be applied for more complex antenna structure like, rectangular, pentagonal, hexagonal etc. Proposed algorithm will be effective and improve the global solutions when we involve more processors .The SIMO algorithm on parallel computers can improve convergence rates to the global solution as long as individual fitness evaluations require the same amount of time. This method hopefully provides the simplification in the field of bio-inspired computation and gives new dimensions for upcoming challenges.

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