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# An Excavated PSO-SQP Mechanisms for an Effective Radar Transmission in MIMO-OFDM Communication Systems

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**Abstract**: In multiple input multiple output (MIMO) radar systems, the design and development of orthogonal frequency division multiplexing (OFDM) – linear frequency modulation (LFM) waveforms is one the most challenging and crucial tasks. Similar to this, increasing the pulse properties of spatially synthesised signals is also crucial in MIMO systems since it makes it possible to successfully eliminate grating sidelobes. Various joint optimization strategies are established in the various existing research works to enhance the overall performance of radar communication systems. Even yet, it has drawbacks including harder to understand computations, false detection rates, and reduced efficacy. Therefore, the proposed work intends to develop an integrated particle swarm optimization (PSO) – sequential quadratic programming (SQP) mechanism for improving the pulse compression properties and suppressing the grating sidelobes. Here, a modification is made to the designed LFM waveform to improve its frequency steps while maintaining balanced sidelobe and orthogonal features. By using the different pulse compression properties, the performance and outcomes of the proposed PSO-SQP based joint optimization model are evaluated and compared through simulation analysis. In this assessment, the average pulse compression, cross correlations, transmit beam patterns, and correlation properties are evaluated for varying spatial synthesis signals for the existing methods with the proposed method. Moreover, the estimated values of these parameters are compared with the conventional and proposed PSO and joint optimization techniques. The proposed method produced better results as compared with the existing methods with respect to various pulse compression properties such as auto-correlation side lobe peaks (ASP) and cross-correlation side lob peaks (CP). Based on the results, it is found that the proposed mechanism is capable of achieving the best ASP (19.4 dB), CP (14.02 dB) and ASLE (0.3745) among all, so assures the high range of resolution of the radar communication system.

**Keywords:** Linear frequency modulation (LFM), Multiple input and multiple output (MIMO), Orthogonal frequency division multiplexing (OFDM), Particle swarm optimization (PSO), Sequential quadratic programming (SQP).

## 1. Introduction

In an ancient time, the multiple input multiple output (MIMO) technology [1, 2] has gained an increased attention by many researchers due to its degree of freedom in optimization. Consequently, the linear frequency modulated (LFM) signals are widely used in many application systems like target detection, jamming recognition, and radar imaging applications [3, 4]. Generally, the MIMO is defined as an antenna based technology [5] used for enabling the wireless communications, where more number of antennas are placed at transmitter and receiver sides. The advantages of using this technology are better reliability, spatial multiplexing, and diversity. Similarly, the OFDM is a multi-carrier modulation technology that offers various sub-streams to segregate the transmitted bit stream [6]. At the transmitting side, the arrays are segregated into varying sub-arrays [7-9], and at the receiver side, an advanced beams are used to receive the signal. In this framework [10-13], the received signal is isolated and the transmitted signal is isolated to other portions with minimal cross-relationship. The major benefits of using MIMO communication systems [14, 15] are better recognition capacity, capture attempt change, and speed in clutter. In recent days, most of the research works highly concentrated on designing the OFDM-LFM [16, 17] waveforms, where the moving target is detected by the radar signals. Moreover, the existing works object to enhance the ambiguity function of radar wideband by developing an optimization based methodologies. Moreover, there are different ways are used to reduce the sidelobes of LFM signals [18-20], where the key factor is to minimize the range of phase coded signals. The existing spatial synthesis signals of conventional OFDM-LFM systems have the limitations [21-23] of reduced performance in target detection, increased false alarms, and inefficient target embedding. Therefore, the proposed work objects to implement a new joint optimization model for improving the design of OFDM-LFM waveforms with better pulse compression property. Also, the proposed system intends to obtain the lower sidelobe level, constant envelope and orthogonality. Following are the paper's primary research goals:

- To enhance the functioning of radar communication, the linear frequency modulated (LFM) signals are effectively used in the proposed framework.
- To deploy efficient OFDM-LFM signals, an advanced particle swarm optimization (PSO) mechanism is utilized.
- To efficiently reduce the side lobes based on joint optimization, the PSO integrated sequential quadratic programming (SQP) mechanism is deployed.
- To validate the performance and efficacy of the proposed communication model, an extensive simulation has been carried out using various parameters.

The remaining portions are separated into the following categories: In section 2, various optimization approaches are discussed that are employed in MIMO-OFDM systems to enable effective radar communication. In section 3, a thorough description of the PSO-based communication system is provided. In section 4, the simulation and comparison findings of the proposed optimization-based communication mechanisms are validated. Finally, section 5 provides a summary of the entire study along with its future scope.

## 2. Related works

This section examines a few of the traditional optimization methods that are employed in MIMO-OFDM communication systems to ensure a successful radar transmission. Additionally, it examines each mechanism's benefits and drawbacks in light of its distinguishing characteristics and primary purposes.

In [17] developed a new communication strategy, named as, radar communication (RadCom) precoder scheme for enhancing the detection performance and communication capacity of radar. The key factors of this paper were to minimize the complexity, ensure energy efficiency, and communication capacity. Moreover, the optimum beam power allocation was performed to minimize the UE requirements. However, it has the problems increased complexity in computations, difficulty in understanding, and high time consumption. In [24] suggested a differential phase shift keying (DPSK) modulation scheme for enabling an efficient communication in MIMO-DFRC systems. The purpose of this work was to optimize the performance of radar system by improving the parameters of average transmit power, error rate of user, and better link quality. In this model, the beam pattern was constructed to reduce the interference produced by the radar receiver. In [25] suggested a PSO strategy for optimally allocating power across transmitting antennas with reduced BER. The important factor of this work was to perform an efficient power allocation in the MIMO-OFDM systems using PSO mechanism.

In [26] designed a correlated LFM-PV waveform for improving the communication efficiency of MIMO radar systems. In this work, an adaptive clonal selection (ACS) algorithm incorporated with SQP based joint optimization model is developed. The constrained beam pattern problem was considered as the bi-objective optimization problem, which could be efficiently solved with better temporal characteristics. It also objects to construct the LFM-PC angular waveforms according to the spatio-temporal characteristics. In paper [27], a quantum PSO technique was implemented to generate the waveforms for MIMO radar applications. The purpose of this paper was to minimize the autocorrelation sidelobe peak (ASP) and cross correlation peak (CP) at multiple target resolution. Here, the simulation analysis was carried out with normal and uniform distributions. Table 1 analyzes various existing optimization techniques with its limitations.

According to this literature review, it is analyzed that the conventional works are mainly focused on improving the target performance, and minimizing the sidelobes of radar communication systems by designing an effective LFM waveforms. The proposed objects to implement a new joint

Table 1. Existing optimization techniques

| ***Optimization techniques*** | ***Problems*** |
|---|---|
| Genetic Algorithm (GA) | Minimal scalability and time consuming process. |
| Bee Colony Optimization (BCO) | Poor searching ability and low convergence. |
| Ant Colony Optimization (ACO) | Theoretical analysis is very complex and uncertainty. |
| Stochastic optimization | Exact solution space is not predictable and inefficient. |
| Swarm intelligence | Increased computational cost and local searching problems. |
| Gradient optimization | It does not ensure the global optimality and difficulty in gradient estimation. |
| Joint optimization | Time consuming task and reduced convergence rate. |

Table 2. List of symbols and descriptions

| ***Symbols*** | ***Description*** |
|---|---|
| $w(t)$ | Rectangular window |
| $T$ | Time period |
| $\mu$ | Chirp rate |
| $MB_w$ | Modulated bandwidth |
| $f_c$ | Carrier frequency |
| $f_p$ | Centre frequency |
| $c_a$ | Code of frequency |
| $\Delta f$ | Frequency step |
| $\tau$ | Delay time |
| $\theta_h$ | Direction of beam |
| $a$ | Position |
| $L_d$ | Lower bound |
| $U_d$ | Upper bound |
| $v_i^t$ | velocity of particles |
| d | Distance |
| $v_{min}$ | minimum velocity |
| $v_{max}$ | maximum velocity |
| $c_1, c_2$ | learning factors |
| $r_1, r_2$ | random numbers |

optimization mechanism for suppressing the sidelobes and improving the pulse properties of the communication system. In the proposed work, a modified PSO algorithm is utilized to develop a joint optimization technique for obtaining the best optimal solution to find the optimal frequency codes. When compared to the existing techniques, the proposed technique has the major benefits of simple computational steps, easy to understand, increased convergence rate, and minimal time consumption.

## 3. Research methodology

This part provides a detailed explanation of the research process along with the necessary mathematical modelling and designing steps. This work's primary contribution is to provide an effective joint optimization mechanism by utilizing the features of an advanced particle swarm optimization (PSO) and sequential quadratic programming (SQP) mechanisms for designing an optimal OFDM-LFM waveforms. Also, it intends to select the frequency codes and phases for suppressing the high grating sidelobes with ideal orthogonal property. The list of symbols used in this work and its corresponding descriptions are shown in Table 2.

### 3.1 Radar signal modeling using OFDM-LFM

Pulse compression is one of the popular mechanisms extensively used in the communication systems for minimizing the peak power of radar. It allows the proper utilization of long pulses based on controlling operations, in which the longer pulse is used at the transmitter side. The transmit antennas in the MIMO systems can transmit the signals with varying carrier frequencies that is termed as the OFDM coded waveform. The OFDM-LFM waveforms are mainly developed for interchanging the fixed frequency signals. Fig. 1 depicts the sample LFM signals, which are the two different models of LFM obtained by using matched filtering technique. Generally, the LFM signals comprise the inphase and quadrature band signals, which are entirely depends on the scientific condition of chirp signal. Moreover, it is also defined as the frequency balanced waveform, where the carrier frequency can vary over the particular time period. In this model, the energy is widely spread in the frequency areas by using these waveforms, and its arithmetic expression is represented as follows:

$$w_a(t) = r(t)e^{j2\pi(f_c t+(1/2)\mu t^2)} \tag{1}$$

$$r(t) = \{1, \ -\frac{T}{2} \le t \le T/2 \ 0, \qquad Else \tag{2}$$

$$\mu = MB_w/T \tag{3}$$

$$f_c = f_p + c_a\Delta f \tag{4}$$

Where, $w(t)$ indicates the OFDM-LFM waveform, $r(t)$ is the rectangular window, $T$ denotes the time period, $a = 1,2, \dots A$, $\mu$ represents the chirp rate, $MB_w$ defines the modulated bandwidth, $f_c$ is the carrier frequency, $f_p$ indicates the centre frequency,

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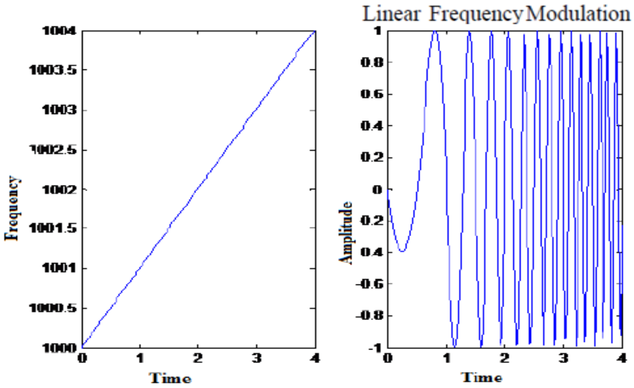


(a) (b)

Figure. 1 Sample LFM signals (a). Model 1 and (b). Model 2

$c_a$ is the code of frequency, and $\Delta f$ is the frequency step. According to the signal processing structure of radar communication system, the receiver beamformer by the space time matched filtering technique are as follows:

$$f(\theta,\theta_h,\tau) = \int_{-\infty}^{\infty} y(\theta,t)y^*(\theta_h,t-\tau)dt \quad (5)$$

Where, $\tau$ indicates the delay time, and $\theta_h$ is the direction of beam. If $\theta_h = \theta$, the pulse compression rate is obtained that is corresponding to the autocorrelation model of spatial synthesis signal. Else, the cross correlation function is obtained that lies in two different locations. By using the function $f(\theta,\theta_h,\tau)$ , the process of target detection is enhanced for instance, the autocorrelation sidelobes may leads false detection, which creates the interference among various targets. The best way to analyze and optimize the autocorrelation function is the tuning of compression property for target detection as mentioned in Eq. (5).

### 3.2 Pulse compression analysis

The OFDM is a kind of spread-spectrum technology, where the carriers are transmitted through the single communication route. Also, each sub carrier can transport the little fraction of whole signal. Typically, the OFDM signals are created basedon the selection of modulation scheme with the specific number of bits such as binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), and quadrature amplitude modulation (QAM). The fundamental block representation of OFDM system is shown in Fig. 2.

Based on the signal model, the results of pulse compression of the spatial synthesized signal are analyzed, and the results are given in below:

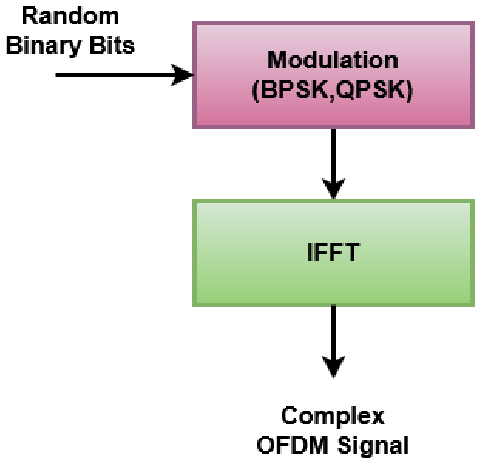


Figure. 2 Structure of OFDM

$$f(\theta,\tau) = \sum_{m=1}^{M} e^{j2\pi f_m \tau}\zeta_0(\tau) + \sum_{v=1}^{M-1} R_v(\tau) + \sum_{n=1}^{M-1} Z_n(\tau) \quad (6)$$

Where,

$$\zeta_u(\tau) = \int_{-\infty}^{\infty} r(t)r(t-\tau)e^{j\pi|\mu t^2-\mu(t-\tau)^2|}e^{j2\pi u t}dt \quad (7)$$

$$R_v(\tau) = \sum_{a=v+1}^{A} e^{j2\pi f_{c-v}\tau} e^{\frac{j2\pi v d \sin(\theta)}{\lambda}} \zeta_{f_c-f_{c-v}}(\tau) \quad (8)$$

$$Z_n(\tau) = \sum_{a=1}^{A-n} e^{j2\pi f_{c+n}\tau} e^{\frac{-j2\pi n d \sin(\theta)}{\lambda}} \zeta_{f_c-f_{c+n}}(\tau) \quad (9)$$

The Eq. (5) represents the main lobe, while the last two terms portray the left and right side lobes respectively. Then, the frequency code $c_a$ is set as$a-(A+1)/2$, hence the carrier frequency at $a^{th}$ position is represented as$f_c = c_a \Delta f$. Based on these models, it is analyzed that the same frequency step and modulation bandwidth can create the grating sidelobes at disparate positions.

### 3.3 PSO-SQP based OFDM-LFM system

Typically, the PSO is one of the most popular optimization technique increasingly used in many application systems, due to their improved performance, convergence speed, and searching solution. It is a kind of meta-heuristic optimization model that is more suitable for solving the complex problems with the suitable solutions. In the existing works, the different types of optimization techniques are used for enabling the reliable communications in the MIMO-OFDM systems. But, it faced some complications associated to the parameters of complex mathematical calculations, reduced speed of processing, requires more number of iterations, and reduced efficacy. Therefore, the proposed technique objects to utilize an enhanced PSO technique for

MIMO-OFDM systems. Here, the joint optimization mechanism is developed by using an integrated PSO model to consecutively search the optimal frequency codes and initial phase vector. In this work, the frequency steps are selected based on the optimization process, since it is affected by the code of frequency. Therefore, it is more essential to implement the optimization methodology for optimizing the frequency codes with added phases. For this purpose, the joint optimization model based on an integrated PSO-SQP mechanism is implemented to design an OFDM-LFM waveforms. In which, the PSO technique is used to perform optimization, and the SQP model is utilized to select the phases.

Moreover, the different types of frequency codes are considered in this model, where the PSO is used to attain the better quality of design. By using an integrated PSO-SQP methodologies, two variables are perfectly optimized in a successive way. In this algorithm, the particle initialization is performed at first with X number of particles, which are randomly move in the searching space. The initial position updation is performed with respect to time t is represented as follows:

$$x_i^t = (x_{i1}^t, x_{i2}^t, \dots \dots, x_{id}^t)^T \tag{10}$$

$$x_{id}^t \in [L_d, U_d] \tag{11}$$

Where, $L_d$ *and* $U_d$ are the lower and upper bounds respectively. Then, the velocity of particles are updated by using the following model:

$$v_i^t = (v_{i1}^t, v_{i2}^t, \dots \dots, v_{id}^t)^T \tag{12}$$

$$v_{id}^t \in [v_{min,d}, v_{max,d}] \tag{13}$$

Where, $v_i^t$ is the velocity of particles at time t, d indicates the distance, $v_{min}$ represents the minimum velocity, and $v_{max}$ is the maximum velocity. Consequently, the position of swarms $p_i^t$ are updated as shown in below:

$$p_i^t = (p_{i1}^t, p_{i2}^t, \dots \dots, p_{iD}^t)^T \tag{14}$$

Moreover, the global optimal position of the particles are updated as follows;

$$p_g^t = (p_{g1}^t, p_{g2}^t, \dots \dots, p_{gD}^t)^T \tag{15}$$

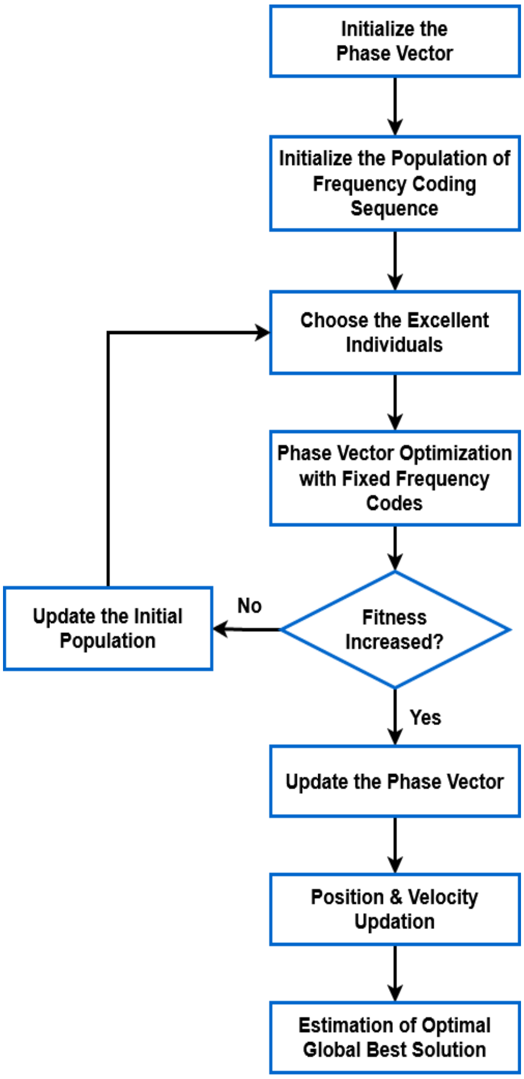


Figure. 3 Working flow of the proposed system

Then, the position updation at time t and t+1 illustrated as follows:

$$v_{id}^{t+1} = v_{id}^t + c_1 r_1^t (p_{id}^t - x_{id}^t) + c_2 r_2^t (p_{gd}^t - x_{id}^t) \tag{16}$$

$$x_{id}^{t+1} = x_{id}^t + v_{id}^{t+1} \tag{17}$$

Where, $c_1, c_2$ are the learning factors. The convergence rate of this optimization mechanism is highly improved, and its falling range is restricted with the random numbers of $r_1$ and $r_2$ lies in the range of [0 to 1]. The combination of PSO with SQP is more suitable the radar communication system, in which the frequency code is optimized using PSO and phase vector selection is accomplished by using SQP. Moreover, the steps involved in the PSO integrated SQP joint optimization model are described in below:

Step 1: Phase vector initialization;
Step 2: Initialization of frequency coding sequence;

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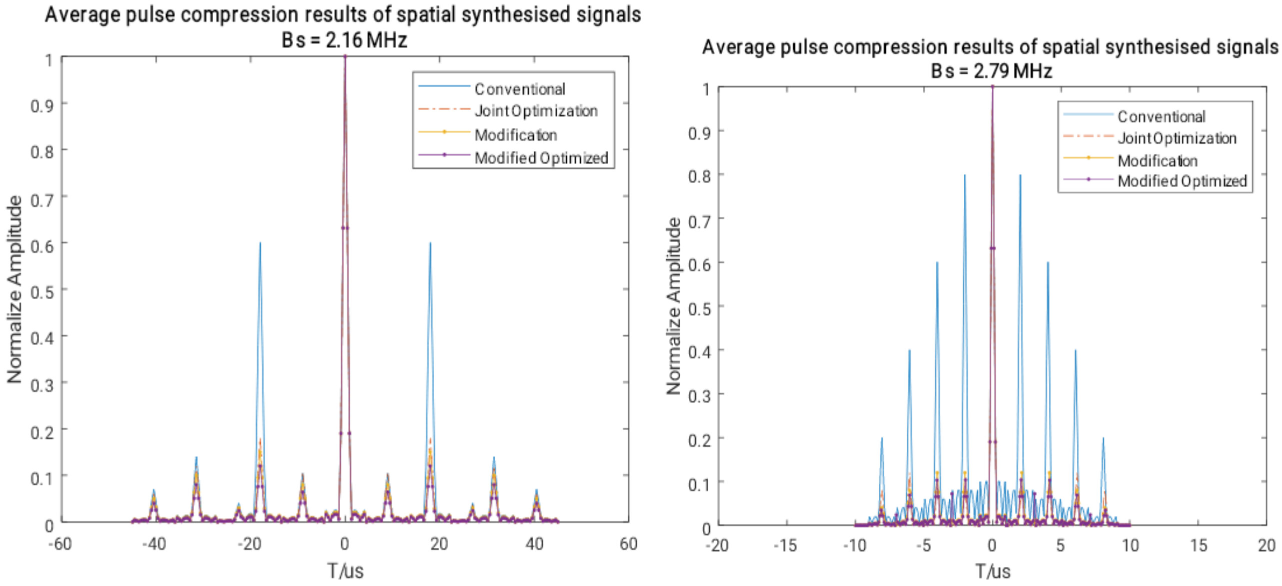
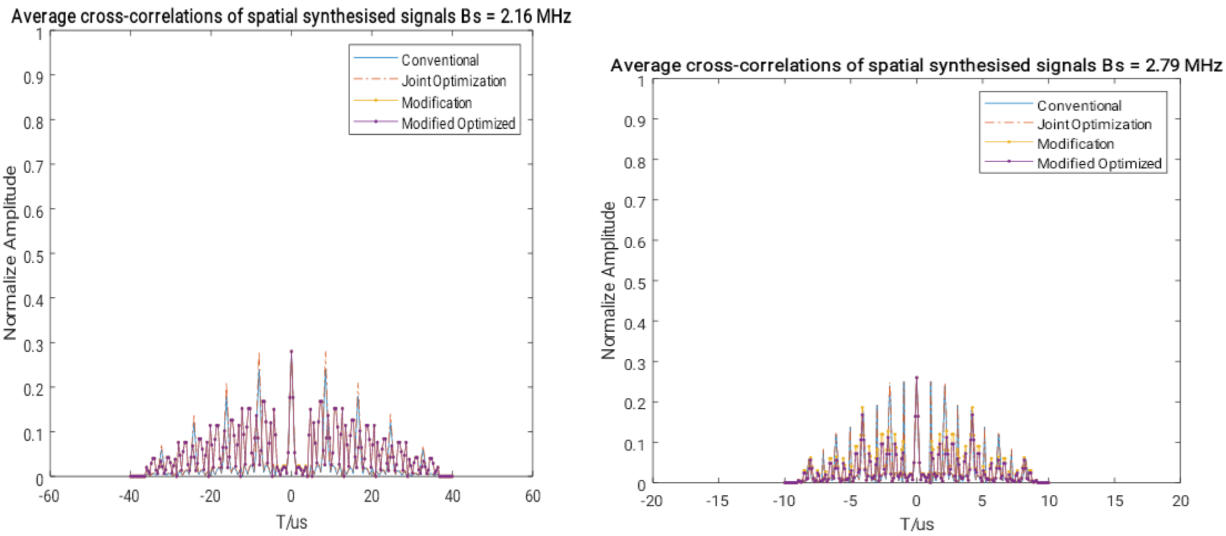



(a) (b)

Figure. 4 Average pulse compression signals: (a) $B_s$ = 2.16 MHz and (b) $B_s$ = 2.79 MHz




(a) (b)

Figure. 5 Average cross-correlation analysis: (a) $B_s$ = 2.16 MHz and (b) $B_s$ = 2.79 MHz

Step 3: Estimating the position and velocity of vectors for obtaining the Pbest value;
Step 4: Perform phase optimization based on the velocities;
Step 5: Optimize the phase vector with fixed frequencies;
Step 6: Update the position and velocity to obtain the Gbest value;
Step 7: The stopping criterion is reached once the global best fitness is identified;

## 4. Results and discussion

The simulation results of the suggested radar communication approach are examined and compared in this section utilizing a variety of evaluation metrics. The effectiveness and higher performance rate of the suggested PSO-SQP based joint optimization mechanism are further illustrated using a few design samples. This technique is mainly developed for optimizing the frequency codes and phases in order to suppress the high grating sidelobes, where the pulse compression is also concentrated for improving the reliable communication. Here, the grating sidelobes are minimized based on the modification of optimization process. The general parameters considered in the PSO mechanism are initial population, number of particles for phase optimization, and best global function. Here, two LFM waveforms are designed in the range of $B_s$ = 2.16MHz and 2.79 MHz respectively for comparison.

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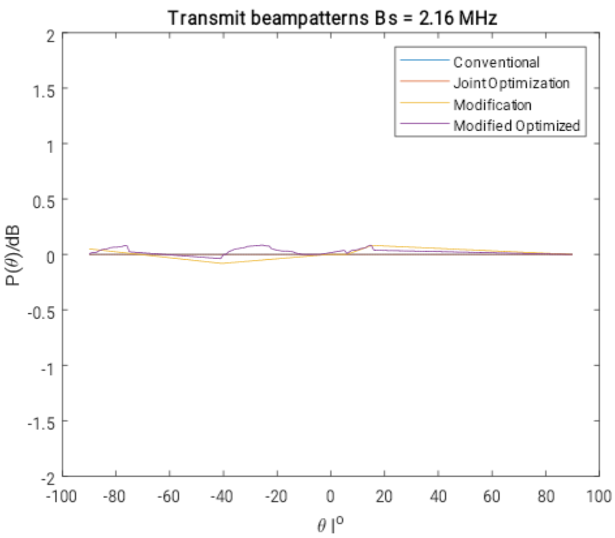
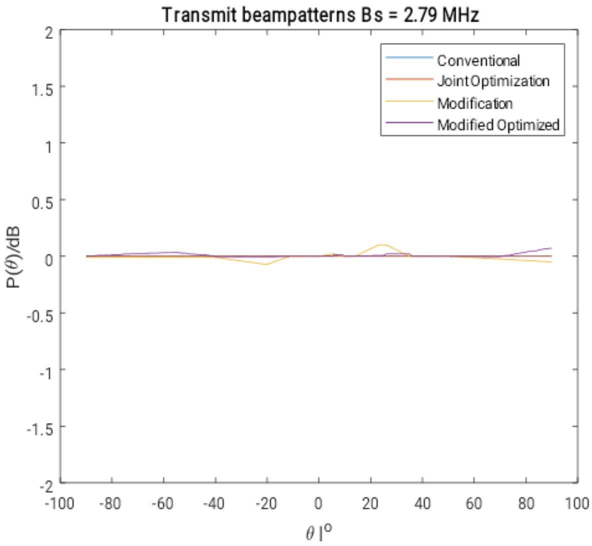



(a)




(b)

Figure. 6 Transmit beam pattern analysis: (a) $B_s$ = 2.16 MHz and (b) $B_s$ = 2.79 MHz

Initially, the average sidelobes of the waveforms are estimated for the proposed PSO-SQP based joint optimization technique as shown in Fig. 4. Here, the number of grating sidelobes of the conventional optimization mechanisms may be greater than the proposed model at some instances. Due to the inclusion of sink-like functions in the proposed model, there may be a chance for small peaks in the waveforms. Moreover, the false detection is mainly caused due to the grating sidelobes, and its waveforms are synthesized in the proposed model by using the PSO-SQP model. Hence, the proposed joint optimization mechanism outperforms the conventional approaches with an improved average pulse compression results.

In this analysis, the pulse compression properties of the spatial synthesis signals are mainly estimated to determine the target detection performance of the optimization model. Moreover, the spatial cross correlation functions are estimated to determine the target detection performance at multiple targets. Figs. 5 (a) and (b) depicts the average cross correlation analysis of the existing and proposed optimization mechanisms for both synthesized signals of $B_s$ = 2.16 MHz and 2.79 MHz respectively. During this analysis, the cross correlation levels of the designed waveforms are compared, where the property is not improved in the existing methodologies compared to the proposed model.

Same as the autocorrelation analysis, the grating loves are suppressed based on the modifications done in the optimization process. The designed waveforms of the proposed technique result an improved performance in the cross correlation analysis. Similar to that, the transmit beam pattern analysis is performed for determining the difference between the joint optimization model and orthogonality as shown in Fig 6. According to the obtained results, it is identified that the transmit beam patterns of the existing and proposed models are entirely orthogonal. Due to the relaxation of frequency steps, it is not satisfied in the modified waveform, but which are approximately orthogonal in the omnidirectional pattern.

Fig. 7 shows the pulse compression analysis is performed to illustrate the principles of grating sidelobes. Based on the analysis, it is identified that the sidelobes can be eliminated by improving the diversity in frequency step and modulation bandwidth using the joint optimization model.

By using the proposed PSO-SQP optimization model, the time duration, bandwidth, arbitrary numbers and frequency steps are efficiently optimized for designing the OFDM-LFM waveforms. The correlation properties considered in this analysis are M=8, T=100$\mu s$ and B= 3MHz as shown in Table 3, and it also encompasses the parameters of autocorrelation sidelobes, mean cross correlation peals, and mean ASPs. Based on the results, it is determined that the PSO-SQP based joint optimization mechanism could effectively reduce the ASPs at varying modulation bandwidths. As a result, the suggested joint optimization mode performs better than the current optimization procedures. Table 4 compares the radiation dull depth of the conventional and proposed optimization techniques. When compared to the other optimization methods [28], it is analyzed that the proposed PSO-SQP optimization technique performs the best with a least radiation null notch at 125.8dB. With the help of our developed discrete valued phases, it is possible to create a beam forming network and obtain great

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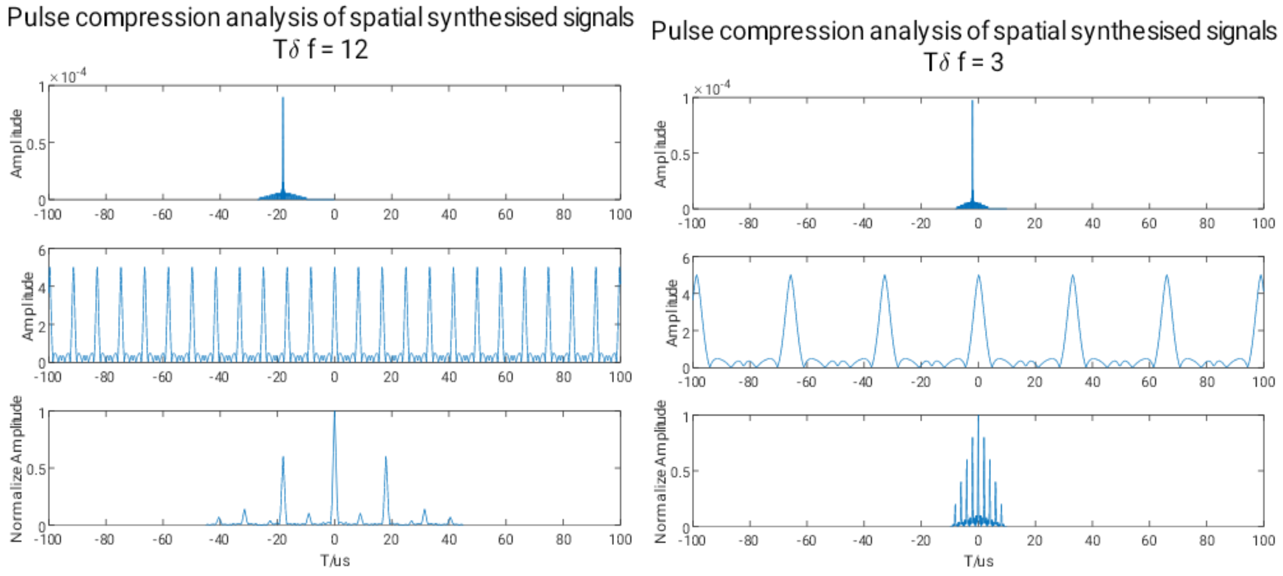


(a) (b)

Figure. 7 Pulse compression analysis: (a) for the spatial synthesis signals Tδf = 12 and (b) for the spatial synthesis signals Tδf = 3

Table 3. Correlation properties with M=8, T=100$\mu s$ and B= 3MHz

| **Method** | **Bs, MHz** | **2.72** | **2.44** | **2.16** | **1.81** | **1.46** |
|---|---|---|---|---|---|---|
| Conventional | Max ASP | 0.6499 | 0.4133 | 0.5208 | 0.2060 | 0.3399 |
| | Mean ASP | 0.6420 | 0.4102 | 0.5208 | 0.1994 | 0.3261 |
| | Mean CP | 0.5674 | 0.6405 | 0.5341 | 0.6525 | 0.6367 |
| Joint Optimization | Max ASP | 0.2061 | 0.1745 | 0.1302 | 0.1148 | 0.1384 |
| | Mean ASP | 0.2036 | 0.1724 | 0.1288 | 0.1138 | 0.1373 |
| | Mean CP | 0.5539 | 0.5338 | 0.5292 | 0.5312 | 0.5366 |
| Modified | Max ASP | 0.2381 | 0.1766 | 0.1376 | 0.1284 | 0.1232 |
| | Mean ASP | 0.2237 | 0.1748 | 0.1354 | 0.1274 | 0.1214 |
| | Mean CP | 0.4429 | 0.3639 | 0.3527 | 0.3503 | 0.3829 |
| Optimization Modified (PSO-SQP) (Proposed) | Max ASP | 0.1825 | 0.1602 | 0.1256 | 0.1053 | 0.1126 |
| | Mean ASP | 0.1856 | 0.1625 | 0.1156 | 0.1054 | 0.1021 |
| | Mean CP | 0.4251 | 0.3541 | 0.3421 | 0.3385 | 0.3592 |

Table 4. Optimized radiation depth analysis

| ***Techniques*** | ***Radiation null depth (dB)*** |
|---|---|
| Enhanced Simulated Annealing (ESA) | -70 |
| Phase Only Variable Metric Method (POVMM) | -105 |
| Jaya Optimization | -124.4 |
| Modified (PSO-SQP) (Proposed) | -125.8 |

Table 5. Average ASP analysis

| ***Optimization techniques*** | ***Average ASP*** | |
|---|---|---|
| | ***Normalized value*** | ***In dB*** |
| SA with iterative search | 0.1525 | -16.33 |
| GA with iterative code selection | 0.1471 | -16.64 |
| ACO with hamming scan | 0.1293 | -17.77 |
| Jaya optimization | 0.1223 | -18.25 |
| Modified (PSO-SQP) (Proposed) | 0.1142 | -19.4 |

performance at a reasonable price. Table 5 to Table 7 presents the comparative analysis of the conventional and proposed optimization techniques based on the parameters of autocorrelation sidelobe peak level (ASP), cross correlation (CP), auto correlation sidelobe energy (ACSE), and cross correlation energy (CCE). For fair comparison, ASP and CP are normalized to the sequence length. Based on the results, it is found that the proposed mechanism is

Table 6. Average CP analysis

| Optimization techniques | Average CP | |
|---|---|---|
| | Normalized value | In dB |
| SA with iterative search | 0.2798 | -10.45 |
| GA with iterative code selection | 0.2666 | -11.48 |
| ACO with hamming scan | 0.2068 | -13.68 |
| Jaya optimization | 0.2078 | -13.64 |
| Modified (PSO-SQP) (Proposed) | 0.1989 | -14.02 |

Table 7. Average ASP and CP analysis

| Optimization algorithm | Average ASLE | Average CCE |
|---|---|---|
| SA with iterative search | 0.4398 | 0.4852 |
| GA with iterative code selection | 0.4299 | 0.4754 |
| PSO with Hamming scan | 0.4306 | 0.4681 |
| ACO with hamming scan | 0.3993 | 0.4442 |
| Jaya optimization | 0.3828 | 0.4558 |
| Modified (PSO-SQP) (Proposed) | 0.3745 | 0.4352 |

capable of achieving the best ASP (19.4 dB) and ASLE (0.3745) among all, so assures the high range of resolution of the radar communication system.

## 5. Conclusion

This paper presents a new joint optimization model by incorporating the PSO and SQL mechanisms for designing the OFDM-LFM waveforms. The purpose of this work is to enhance the pulse compression properties of the synthesized signals by using the optimization mechanism. In MIMO radar communication system, improving the pulse compression property is gained a significant attention by many researchers. In accordance with the signal processing design, the pulse compression property of spatially synthesized signals plays a significant role in MIMO radar. A joint optimization method is proposed to select the frequency codes and the phases for high grating sidelobe suppression, which results in sidelobe feature reduction with ideal orthogonality. This method is based on the pulse compression analysis of spatially synthesized signals of the OFDM LFM waveform. The proposed mechanism's effectiveness is verified through simulation and compared with the common joint optimization strategies based on the correlation features. The analysis of the data shows that the suggested PSO-SQP combined optimization mechanism outperforms the other methods with better pulse compression properties such as ASP results 19.4 dB and CP results 14.02 dB as per the simulated results. This study can be expanded in the future by using a new hybrid optimization methodology to enhance the functionality of MIMO radar systems.

## Conflict of interest

The authors declare no conflict of interest

## Author contributions

The paper background work, conceptualization, methodology, dataset collection, implementation, result analysis and comparison, preparing and editing draft, visualization have been done by first author. The supervision, review of work and project administration, has been done by second author.

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