Algorithms and Simulation Analysis of Optical Waveguide Devices to Generate Supercontinuum

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Abstract. With the development of the times, our life is becoming more and more intelligent. In this regard, we have also made great progress in the field of communication intelligence. But we still need optical wavelength devices to generate ultra-continuous spectromets that can be used in the field of communications. In this regard, the purpose of this paper is to study the optical wave guide device to generate ultra-continuous spectrum algorithm, and its simulation and analysis. The experiment in this paper begins after careful consideration of the security of user data and some trade secrets, and on the premise of experimental security, the accuracy of the algorithm is measured and simulated by using sandbox simulation based on computer technology. The experimental results show that the algorithm can increase the speed of ultra-continuous spectrum of optical wave guide device by about 50%. And in the simulation simulation application, the stability is good.

Keywords: Optical Wave Guide Device; Ultra-Continuous Spectrum; Simulation Analysis; SEN Algorithm

1. Introduction.
Our current strategy for the generation of optical waveguide devices for the entire optical communication industry is mainly considered. Because optical waveguide is the process of making light propagate in the medium of specific manufacture, and the process of light introduction[1]. Optical waveguide devices use the principle of total reflection of light to make a film with a refractive index higher than the upper and lower layers. Adjust the angle of incident light, incident to the film and limit the propagation of this beam of light in the guide layer, so as to transmit the optical signal [2]. In this way, supercontinuum is generated. Supercontinuum can be used in many fields. It includes optical coherence, tomography, spectrum detection, fluorescence lifetime imaging, optical communication, gas detection and so on. Therefore, our aim is to generate supercontinuum instead of other optical signals through algorithm. And carry out simulation analysis to detect its effectiveness, which is our purpose [3].

The early SC was obtained by pumping various nonlinear media with high-power ultrashort laser pulse, which was subject to weak nonlinear effect and high loss; however, after 1978, with the spectral...
broadening phenomenon observed in single-mode fiber by pinaultsc and others, the use of optical fiber to generate SC has become a more ideal way [4]. In 1996, knightjc et al. Proposed the concept of photonic crystal fiber (PCF), through the internal structure design of the fiber, to control its dispersion characteristics, the obtained SC also has more ideal spectral, time spectrum and other characteristics [5]. PCF is different from ordinary optical fiber, usually the core and cladding are the same medium, relying on the designed airhole array to destroy the periodic structure of the thin layer, so as to bind the light wave to the core [6]. Its dispersion characteristics and nonlinear characteristics can be obtained through design: the zero dispersion of the fiber is changed by changing the micro pore structure in the cladding, and the proportion of waveguide dispersion in the fiber dispersion is adjusted, so as to control the dispersion characteristics of PCF; this design also changes the effective mode field area of PCF, making the nonlinear effect strength in PCF core change [7].

After years of development, there are many solutions for the generation of supercontinuum, including CW laser, nanosecond laser, picosecond laser and femtosecond laser. The nonlinear media for supercontinuum generation include PCF, ordinary optical fiber, gain fiber, soft glass fiber, etc. the spectral range of supercontinuum laser can easily cover visible to near-infrared bands. It can also be extended to ultraviolet, mid infrared and even far infrared bands [8]. Supercontinuum light source has also obtained many practical applications, such as optical fiber communication, precise time and frequency measurement, optical coherence tomography and nonlinear spectroscopy [9]. This paper focuses on the algorithm and simulation analysis of supercontinuum generation by optical waveguide devices [10].

2. SEN Algorithm and Model Building

2.1. SEM-Based Program Preferred Evaluation Indicator Empowerment
Structural Equation Model (SEM) is a powerful multi-statistical method based on the variable covariance matrix. SEM consists of two parts, measurement model and structural model, which can analyze both path and factor. And the structural equation model is a kind of verification method, which validates the hypothesis model by the questionnaire data collected.

2.1.1. Questionnaire design and data collection
Based on the above-mentioned system of preferred evaluation indicators, a questionnaire survey is conducted on the importance level of indicators affecting the choice of schemes. According to the difference in the importance of the indicator, the first part of the questionnaire is the basic information of the subject, and the second part is the questions and answers of the 14 program evaluation preferred indicators. Questionnaires are distributed to experts, scholars and project experience in the relevant fields of foundation pit engineering, and the actual sample data are processed after the questionnaire is collected.

2.1.2. Structure equation model is established and fitted
The factor path load in SEM represents the degree of close relationship between factors. The greater the factor load, the higher the influence position of the variable and its great influence. Based on the scheme preferred evaluation index system, the following assumptions are made and the hypothesis model is established in AMOS 23.0 software:

H1: Environmental influence factors have a significant positive effect on the scheme selection;
H2: The total cost factor has a significant positive effect on the scheme selection;
H3: Test operability has a significant positive effect on scheme selection;
H4: The technical feasibility of the scheme has a significant positive effect on the scheme selection;

2.1.3. Model Fit
The test of the fit degree of the initial model is completed in the AMOS23.0 software, and the fitting index used in this paper is $\chi^2$/df, RMSEA, GFI, AGFI, NFI, CFI, etc.

2.1.4. Determines the weight

The weight of indicators at all levels is determined by the standardized factor load of each factor obtained from the last section. Formula (1) is as follows:

$$\beta_i = \frac{L_i}{\sum_{i=1}^{n} L_i}$$

(1)

It represents the weight of indicators at all levels, which indicates the factor load at all levels in SEM, that is, the path coefficient $\beta_i L_i$

2.2. Based on the gray association theory scheme preferred model construction

It is the core idea of gray association theory to judge the degree of correlation between sequences by the similarity of objective curve shapes. The more similar the graphs are, the greater the gray correlation; Conversely, the less correlated.

2.2.1. Raw data transformation

In order to solve the problem of measuring unit differences between different data, the original data need to be unquantified, so as to achieve the goal of unified scale. The two main ways to unify the data outline are:

- Initial value change:
  \[ X^{(1)}_i(k) = \frac{X^{(0)}_i(k)}{X^{(0)}_i(1)} \]  
  (2)

- National transformation:
  \[ X^{(1)}_i(k) = \frac{X^{(0)}_i(k)}{X^{(0)}_i} \]  
  (3)

2.2.2. Calculate the correlation coefficient

With $X^{(1)}_i(k)$ the bus as the bus, calculate the difference between the columns at the corresponding moment: $\Delta_{ij}(k)$

$$\Delta_{ij}(k) = K_{ik}^\gamma((1)) - X K_{jk}^\gamma((1)) \quad k = 1,2, ..., i \neq j \quad (4)$$

Find out the minimum $|\Delta_{ij}(k)|\Delta_{\min}$ and the maximum value of $\Delta_{\max}$. Correlation factor: $\xi_{ij}(k)$

$$\xi_{ij}(k) = (\Delta_{\min} + \eta \Delta_{\max})/(\Delta_{ij}(k) + \eta \Delta_{\max}) \quad (5)$$

Where $\eta \in 0, 1$, usually take 0.5.

2.2.3. Calculate the comprehensive correlation of each sequence $X^{(1)}_i$ $\gamma_i$

$$\gamma_i = \sum_{k=1}^{n} \beta_i \xi_{ij}(k) \quad j = 1, 2, ..., m \quad (6)$$

Sorted according to the comprehensive correlation degree, the highest correlation value is the preferred scheme.

3. Test.
3.1. Select A Different Light Wave Guide Device Made In A Laboratory As The Subject Of The Survey

After searching and contacting, we finally identified a laboratory on optics to conduct an analog experiment with an algorithm for optical wave-conducting devices to generate ultra-continuous spectrometers. We used two sets of algorithms, the first for making optical wavelength devices using today's algorithms, and the second for using optical wavelength devices that were made based on the SEN algorithm. For each of these devices, we produced 10 sets for analysis. The parameters are then compared and analyzed.

3.2. Analysis Test

After the fabrication of the optical waveguide device, we invite the relevant experts in the laboratory to analyze it, analyze the parameters and the actual situation, and test its real use. We overcame the difficulties. In the end, we have developed an optical waveguide device which can generate supercontinuum based on Sen algorithm. The stability of supercontinuum and the stability of the clock in different environments are compared. And make a table to draw analysis and processing. Finally, we measured the data of each group under the guidance of experts in the laboratory, and then analyzed and compared them. Later, we discussed the authenticity and validity of our data by consulting experts in the industry. The final result is whether our experiment is successful or not.

4. Evaluation Results

4.1. Parameter Comparison

| Table 1. The optical wavelength devices constructed by different algorithms produce a parameter comparison of the ultra-continuous spectrum |
|---------------------------------------------------------------|
| **Signal stability** | **The frequency at which it is generated** | **Spectrum stability** |
| Traditional algorithms | Good. | 4Tbit/s | Good. |
| The Sen algorithm | Excellent. | 6Tbit/s | Excellent. |

![Figure 1](image.png)

**Figure 1.** frequency generated by different algorithms

According to the comparative analysis of the above parameters, we can know that our Sen algorithm has better signal stability and spectral stability, and the frequency is still 50% higher, which is a good progress. However, our experiment is done under standard conditions, and its real performance remains to be discussed. Therefore, our next step is to carry out experiments in different environments, so as to get a comprehensive data analysis and comparison, to verify whether our experiment is successful. In this regard, we choose standard conditions, high temperature, severe cold, extreme weather and information shielding to analyze, discuss and deal with our experiments. In order to obtain a more comprehensive experimental data. So we do the next experiment.

4.2. Comparison of Experiments in Different Experimental Environments
Table 2. Comparison of experimental conditions in different experimental environments

| Spectrum stability | Standard situation | High temperature conditions | Cold conditions | Extreme weather | Signal shielding |
|--------------------|--------------------|----------------------------|----------------|----------------|-----------------|
| Traditional algorithms | 94%                | 92%                        | 91%            | 72%            | 16%             |
| TheS EN algorithm   | 99%                | 97%                        | 97%            | 81%            | 41%             |

Figure 2. Comparison of experimental conditions in different experimental environments

Based on the data in Tables 2 and 2, we conclude that the parameters derived by the SEN algorithm in different experimental environments are better than those of traditional algorithms. By comparing the data, such as the data in Table 2, we find that there is a small gap between the traditional algorithm and Sen algorithm in the standard case. However, with the temperature entering the high temperature and low temperature, the traditional algorithm has a weak decline, the Sen algorithm is the same, but still higher than the stability of the traditional algorithm. However, when the weather goes to the extreme, the stability of pop is greatly hindered. The traditional algorithm decreases by 20%, and Sen algorithm also drops by nearly 20%. And when it comes to information masking, we find that the spectral stability of the traditional algorithm is only 16% and that of the algorithm is only 41%. This shows that the spectral stability of Supercontinuum Generated by the two algorithms is unstable when the signal is shielded. Because of the interference of the external environment, the spectrum will produce great fluctuation, and the optical signal will propagate in the medium or even outside the medium. Because the medium will be greatly changed by the information shielding, but when the temperature changes, the influence of the medium is not big. Because the medium we use is less affected by temperature. Because it is an optical medium, it is easily affected by signal interference and other weather conditions such as thunderstorm in extreme weather. So we can tentatively determine the success of this experiment.

4.3. Introduction to the Ultra-continuous Spectrum

Ultra-continuous spectrum is a light source with extremely wide bandwidth, which is generally produced by nonlinear materials using ultra-short pulses with peak power, for example, using flyscond laser pulses to obtain a continuous spectrum covering the entire visible light band through photonic crystal fiber. In optics, when a series of nonlinear effects act on the pumped light, the original pumped light is greatly extended spectrally, for example, by using microstructural fibers, the ultra-continuous
spectrum is obtained. The result is a smooth continuous spectral line, which has no clear explanation for the spread of the ultra-continuous spectrum; There are even studies claiming that the spread of 60nm still calls it the ultra-continuous spectrum. This revived study has produced a variety of new light sources and is used in a variety of fields, including optically lysographic fault scanning, spectrum detection, fluorescence life imaging, optical communication, gas detection, and more. The application of these light sources creates a feedback loop where scientists using ultra-continuous spectromets demand better custom continuous spectromets to meet their specific applications. This has prompted researchers to develop novel ways to produce these continuous spectrums and to develop theories to understand their formation and help future development. As a result, rapid progress has been made in the development of such light sources since 2000.

5. Conclusion.
As shown above, after experiments, it is found that the spectral stability can be improved better by using SEN algorithm than before, especially in various situations, especially in the case of signal shielding and extreme weather. And in the high temperature and cold conditions consistent, more stable. And signal stability and spectrum generation frequency are better than traditional algorithms. But this is not the best result, because when the signal is shielded, his spectral stability is only 41% compared to normal. Therefore, in the future, we should focus on the extreme weather and signal shielding situation, in these areas of research.

Acknowledgments
Preparation of mid-infrared supercontinuum based on ZnSe waveguide.

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