

Finding Best Optimal Parameters and Determining Weight by Taguchi Method in Video Tracking Applications

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Abstract

There are many characteristics that can be calculated by the movement of people, such as distance, speed, slope and difference in length or height for each type of the movement.

For the purpose of finding the most important of which features and high priority weight in the classification of the movement of people, we have been employed Taguchi method to determine the weight of each characteristic and the extent of their influence and weight in determining the behavior and the type of people movement.

In this paper we employ Taguchi method in video tracking application to determine high value of weight for best parameters. We have been relying on the formula Signal to Noise Ratio (S/n) in order to find the most effective characteristic.

Keyword: video tracking, Taguchi method, Optimization, Slope, design Experiment, orthogonal array and best optimal.

1. Introduction

Many challenges facing the process of tracking objects, particularly we spend long time to apply any algorithm for video tracking applications.

In the tracking object systems can extract a variety of features such as distance, speed, displacement, velocity, slope, acceleration, object area, center of the object and others. So we need to implement optimization methods in order to reduce the number of features extraction and determine weights for each feature as well as reducing the experiments and possibilities that lead to the construction of efficient classification system for shape of object movement and as a result at least implementation of the processing extract features time.

Optimization one of stage is utilize to classification type or shape of person movement. Optimization methods are designed to supply the better parameters of system design – parameters that will drive to the highest levels of system quality [1]. Optimization techniques are a powerful or robust set of tools that are important or significant in activity managing a video tracking systems [2].

To classify movement person we will enter group of properties such as distance or displacement, speed or velocity, slope and height difference of object movement to feed Taguchi method in order to determine the most effective property for the purpose of giving it more weight in the process of rating or classification object movement.

The methods are based on the design of experiments to provide near optimal quality characteristics for a specific objective.

2. Related Work

- Israa Hadi and Mustafa Sabah, an improved algorithm is presented by mixing two concepts, first concept found in parallel cat swarm optimization (PCSO) method for solving numerical optimization problems, the second concept found in Average-Inertia Weighted CSO (AICSO) by adding a new parameter to the velocity update equation as an inertia weight and used a new form of the position update equation in the tracing mode of algorithm [3].
- P. W. Tsai and *et al*, The parallel cat swarm optimization (PCSO) method is an optimization procedure designed to solve numerical optimization problems under the conditions of a few population magnitude and a little iteration numbers [4].
- Israa Hadi and Mustafa Sabah, the Taguchi method is widely utilized in the industry for optimizing the product and the process conditions. By selecting the Taguchi method into the tracing mode process of the PCSO method, they suggest an enhanced parallel cat swarm optimization (EPCSO) method with best accuracy and smaller computational time [5].

3. Taguchi Methods

The Taguchi method includes reducing the variant in an operation through powerful design of experiments. It is prepared to improve the fitness of tracking systems and operations where the performance based on many parameters [6].

They are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering [7].

It lets us to predict combination of independent parameters (or input parameters) to give the better result on a dependent parameter. It is used to detect which input parameters have the greater effect [8]. The Taguchi method is widely utilized in the manufacture for optimizing the product and the process conditions [9]. It is consist of two phases:

A. Design of experiment.

B. Analysis of the results to calculate the better possible parameters [6].

The methods are based on the design of experiments to provide near optimal quality characteristics for a specific objective.

In this paper we employ Taguchi method in video tracking application to determine high value of weight to best of parameters.

4. Orthogonal Array

We used orthogonal array to design experiments and it is suit to most experimental situations, a number of orthogonal arrays such as L-4, L-8, L-12, L-16, L-32, L-64.

An orthogonal array is a kind of experiment where the columns for the independent parameters are *orthogonal* to one another.

A t - (v, k, λ) *orthogonal array* ($t \leq k$) is a $\lambda v^t \times k$ array whose entries are selection from a set X with v points such that in each subset of t columns of the array, every t -tuple of points of X shows in exactly λ rows [10, 11].

v is the number of *levels*

k is the number of *parameters*.

t is the *strength*

λ is the *index*

λv^t is the number of experimental *runs*.

5. The Quality Loss Function (QLF)

The quality loss function is based on the measure quality by the number of defects or the defect rate. The quality loss function distinguishes that systems falling between

specific limits are not all equal. The loss is determined by evaluating variation from a specific target [12, 13].

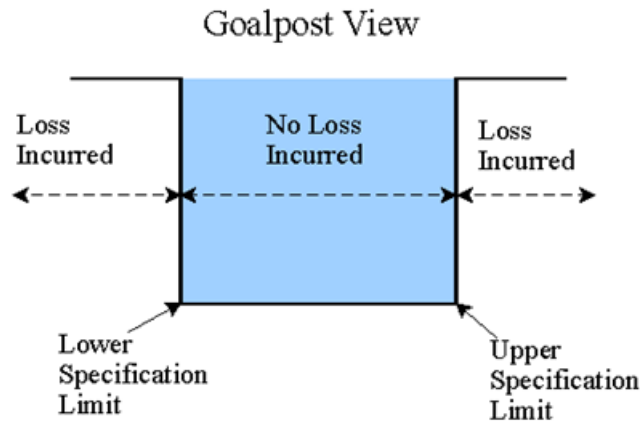


Figure 1. Loss Function Label Diagram

Taguchi's loss function can be represented in quadratic equation below:

$$L = K (Y - M)^2 \dots\dots\dots 1$$

Where Y: Critical performance parameter value.

L: The loss associated with a particular parameter y,

M: The nominal value of the parameter specification.

K: A constant that depends on the system.

(Y-M): Tolerance.

6. The Propose Method to Find Best Parameters

Suggested method consists of five modules as following below in Figure 2:

1. Features Extraction.
2. Design Experiments.
3. Orthogonal Array.
4. Analysis Test of result according to optimal conditions (S/N) ratio.
5. Select of best parameters and determine weight for each it.

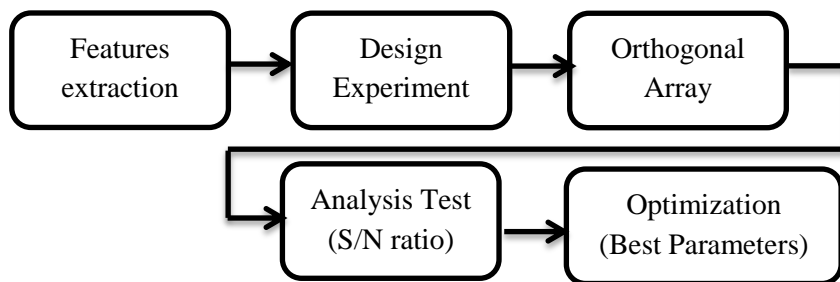


Figure 2. Shows the Suggested Method Stages

6.1. Features Extraction

Feature extraction a kind of dimensionality reduction that powerfully represents interesting parts of an object movement such as distance, speed, displacement, velocity, slope, size and others. It is represented by a compact feature vector [14].

We can supply features extraction to Taguchi method after applied some steps explain as following below in Figure 3.

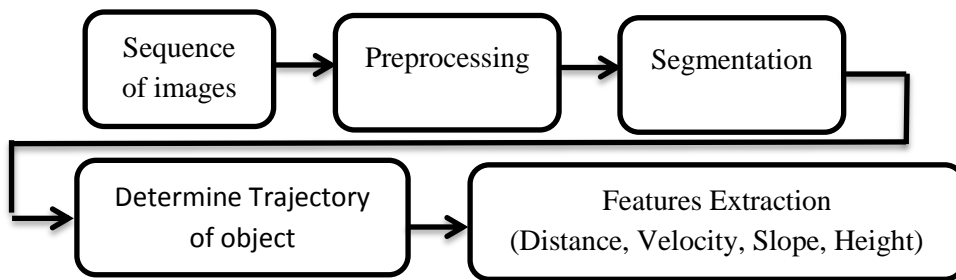


Figure 3. Shows the Extraction Features Stages

6.2. Design Experiment

Design of experiments (DOE) technique more effective in applications and how a number of parameters work together in experiments, it is related to improve select most effect parameters and quality of optimization system by using minimize the number of experiments to predict the best combination of parameters.

Experiment design with all parameters at two levels if the behavior of the parameters are linear, three or four levels when non-linear effects.

In some case, levels of a parameter are including the current value, minimum and maximum and the relations are explain in Figure 4.

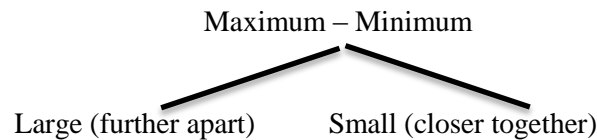


Figure 4. Determining Parameters Design Orthogonal Array

6.3. Orthogonal Array Appropriate

In this research we used L9 or 2-(3, 4, 1).

v is the number of *levels* = 3

k is the number of *parameters* = 4 (Displacement, Velocity, difference Max. Vertical, Slope).

t is the *strength* = 2

λ is the *index* = 1

λv^t is the number of experimental *runs* = $\lambda \times v^t = 1 \times 3^2 = 9$

Table 1. Taguchi Method of Orthogonal Arrays Selector

		Number of Parameters (P)																															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
Number of Levels	2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	
	3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36									
	4	L'16	L'16	L'16	L'16	L'32	L'32	L'32	L'32																								
	5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50																					

L9

Table 2. Orthogonal Array-Three Levels, Four Parameters And Nine Experiments (L⁹(3⁴))

Exp. Run	Columns: parameters			
	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table 3. Explain Number Levels To Each Parameter

Parameters	Displacement	Velocity	Max of vertical	Slope
No. Levels	3	3	3	3
Levels Type	1: Small 2: Medium 3: Large			

6.4. Analysis Test (Signal/Noise Ratio (S/N))

To compute the effect each parameter has on the **output**, the **signal-to-noise ratio** is denoted by S/N, it is needed to be computed for each experiment conducted. S/N is utilized for the analysis of the results [6]. A ratio of the change in output due to the changing parameter vs. changes in things we cannot control.

➤ **Types of Signal to Noise ratio(S/N)**

Taguchi Method analyzes the results using either the ANOVA “Analysis of Variance” Analysis & by the (S/N) ratio Analysis. It is divided to three types as following below:

- **Smaller the Better:** The S/N_S ratio for Smaller the Better is used where the smaller value desire and minimize the response.

$$S/N = -10 \text{Log}_{10} [\text{mean of sum of squares of measured data}] \dots\dots\dots 2$$

The difference between ideal value and measured data is predicted a small value. The common form of S/N ratio is turn into:

$$S/N = -10 \text{Log}_{10}[\text{mean of sum of squares of measured ideal}] \dots\dots\dots 3$$

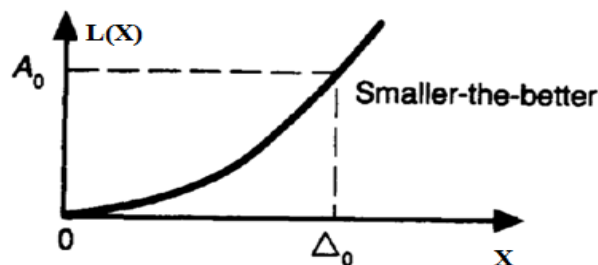


Figure 5. S/N ratio is type of Smaller-The-Better Diagram

- **Larger the Better:** The S/N_L ratio for Larger the Better is used where the largest value desire and maximize the response. We are taking the **reciprocals** of measured data, and applied as following equation below.

$N=-10 \log_{10}$ [mean of sum squares of reciprocal of measured data].....4

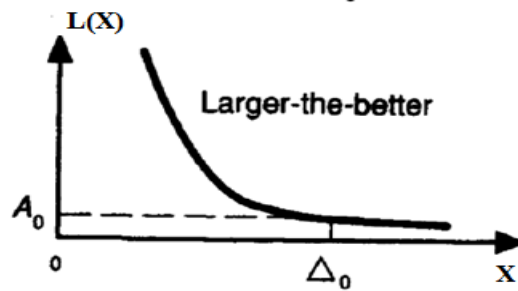


Figure 6. S/N Ratio is Type of Larger-the-Better Diagram

- **Nominal the Best:** The S/N_N ratio for Nominal the better is used where the Nominal or Target value and variation about that value is minimum. It is **MOST** desired, meaning that neither a smaller nor a larger value is desirable.

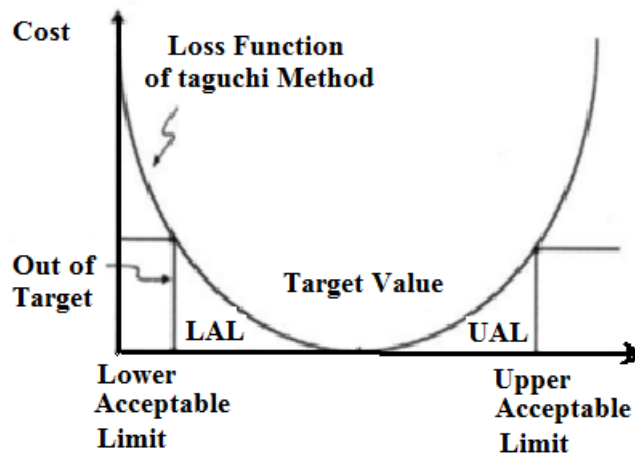


Figure 7. S/N ratio is Type of Nominal-The-Better Diagram

In this research, we take the relationship as following below to determine S/N depend on mean, standard deviation and logarithm relation,

$$S/N_i = 10 \log \frac{\bar{M}^2}{SD^2} \dots\dots\dots 4$$

\bar{M} : **Mean**- It is average of parameters.

$$\bar{M} = \frac{1}{N_i} \sum_{u=1}^{N_i} Data_{i,u} \dots\dots\dots 5$$

SD: Standard Deviation- It is utilized to quantify the amount of variation or dispersion of a set of data values [15, 16].

$$SD^2 = \frac{1}{N_i} \sum_{u=1}^{N_i} (Data_{i,u} - \bar{M}) \dots\dots\dots 6$$

i: Experiment No.

u: Trial No.

N_i: Number of trial for experiment i.

The Nominal is **best** (default) S/N ratio is useful for analyzing or identifying scaling parameters, which are parameters, depend on mean and standard deviation vary proportionally [17].

7. Optimization (Best Parameters)

After design experiments, we need to select best parameters and determine the weight for each parameters then we are utilized S/N ratio to compute the optimal parameter settings by applied equations (4, 5, 6).

We are used Weizmann Database in this research to find best parameters through compute S/N ratio for all parameters, we are used nine movement forms (wave, bend, jack, jump, pjump, run, side, skip, walk).



Figure 8. Movements of People that Have Been Adopted For the Research.

Table 4. It is calculating an Average SN Value for Each Parameter.
A Sample Calculation is shown for Parameter (displacement)

Exp. No.	Parameters				Movi. Form	Trail1	Trail2	Trail3	Mean	SN
	Displ.	Speed	MxDif Height	Slope						
1	1	1	1	1	Wave	1.000	0.001	0.002	0.334	-25.21
2	1	2	2	2	Bend	2.000	1.000	1.414	1.471	9.160
3	1	3	3	3	Jack	5.000	20.809	4.243	10.017	-0.895
4	2	1	2	3	Jump	92.763	73.000	109.29	91.685	14.001
5	2	2	3	1	Pjump	5.831	5.000	2.236	4.355	7.009
6	2	3	1	2	Run	123.102	114.00	144.222	127.11	18.252
7	3	1	3	2	Side	146.086	74.431	109.041	109.85	9.573
8	3	2	1	3	Skip	148.000	85.053	85.053	106.03	9.127
9	3	3	2	1	Walk	149.121	98.127	149.405	132.22	12.949

Table 5. It is Calculating an Average SN values for All Parameters

Exp. No.	Movi. Form	S/N for all parameters			
		Displ.	Speed	MxDif Height	Slope
1	Wave	-25.21	-22.017	3.882	-3.802
2	Bend	9.160	9.509	17.132	-0.532
3	Jack	-0.895	-5.794	6.303	1.979
4	Jump	14.001	14.036	13.975	-0.142
5	Pjump	7.009	7.664	8.454	-0.102
6	Run	18.252	14.992	13.222	5.571
7	Side	9.573	18.073	15.989	-0.057
8	Skip	9.127	22.297	11.245	10.904
9	Walk	12.949	31.743	4.078	-6.492

$$S/N_{\text{Displacemnet_Level1}} = \frac{-25.21+9.16-0.895}{3} = -5.64$$

$$S/N_{\text{Displacemnet_Level2}} = \frac{14.001 + 7.009 + 18.252}{3} = 13.08$$

$$S/N_{\text{Displacemnet_Level3}} = \frac{9.573 + 9.127 + 12.949}{3} = 10.55$$

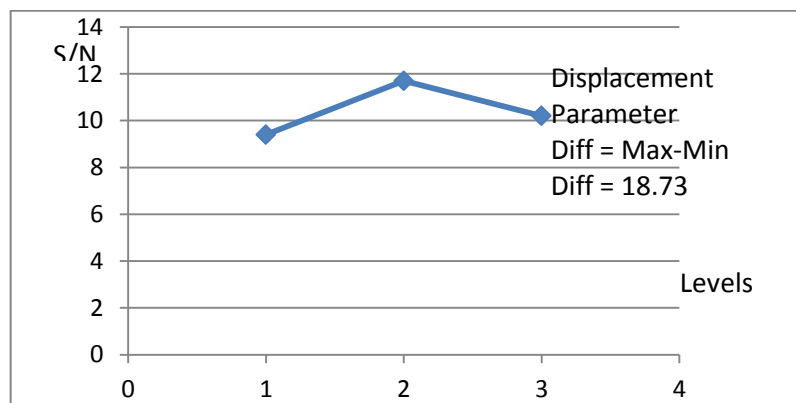


Figure 9. Affect S/N Ratio of Displacement Parameter

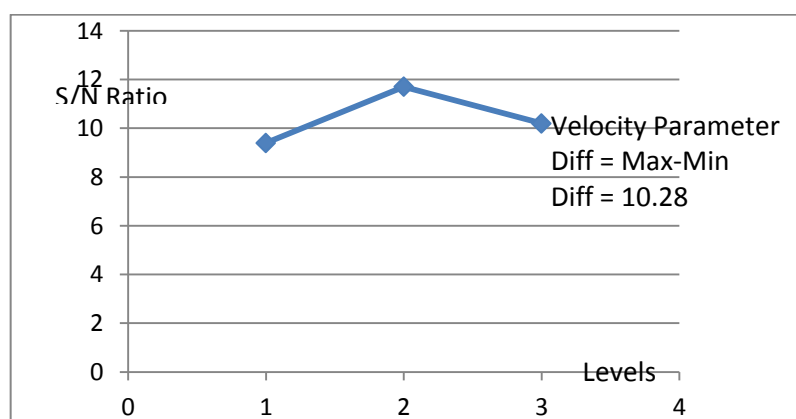


Figure 10. Affect S/N Ratio of Velocity Parameter

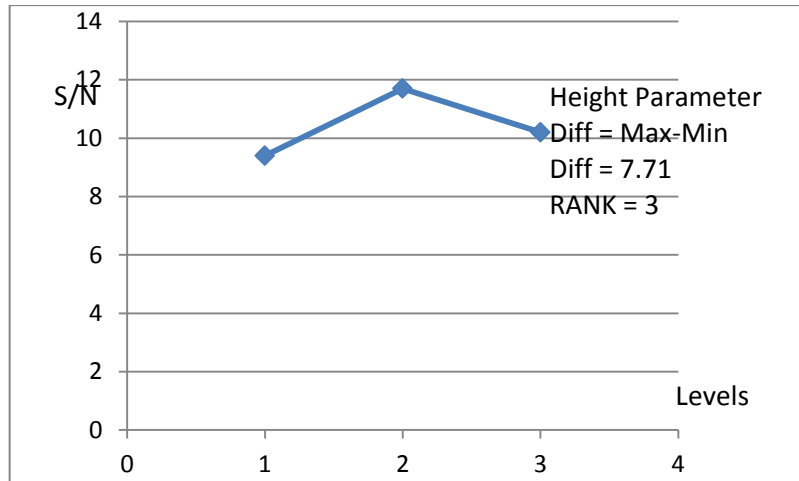


Figure 11. Affect S/N ratio of Height Parameter

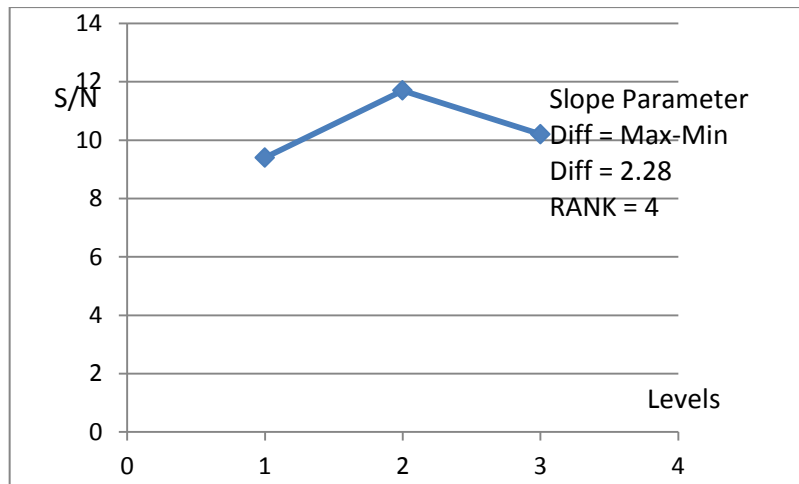


Figure 12. Affect S/N Ratio of Slope Parameter

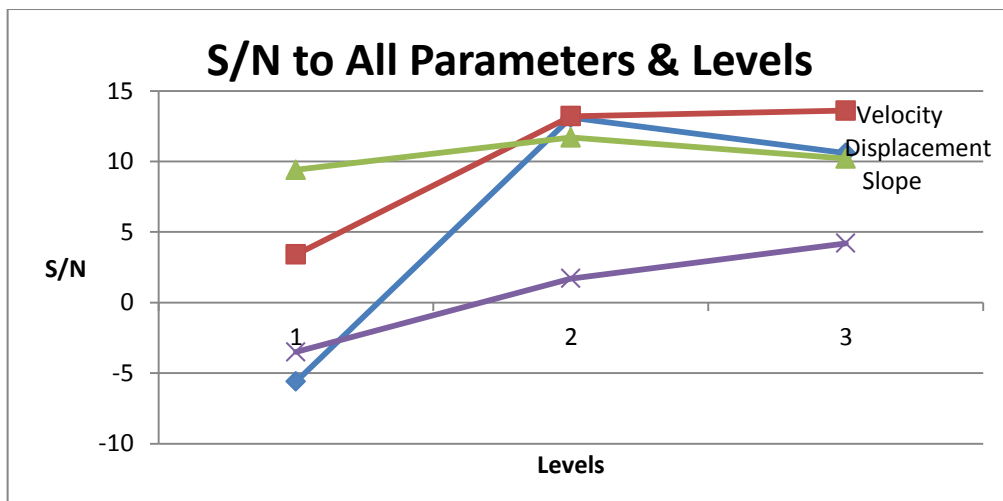


Figure 13. Affect S/N Ratio of All Parameters

We depend on three levels for each parameter and calculate the S/N ratio to them, and determine the maximum and minimum of these levels, then we determine the differences

or delta between them to each parameter according to equation (7) and we compare among parameters to find the maximum value and sort ascending values then we decide the highest value of S/N ratio is best rank.

$$\Delta_{\text{to each parameters}} = (\text{Max}-\text{Min}) \dots \dots \dots 7$$

Table 6. It is Calculated Best Optimization Rank

Level	Displ.	Speed	Height	Slope
1	-5.649	3.364	9.449	-3.465
2	13.087	13.157	11.728	1.660
3	10.550	13.647	10.249	4.247
Max	13.087	13.647	11.728	4.247
Min	-5.649	3.364	9.449	-3.465
Δ=(Max-Min)	18.700	10.30	2.300	7.700
Rank	1	2	4	3

From above table determine the rank for all parameters and find best optimization which appropriates the weight of each parameter.

8. Conclusion

In this research we use Taguchi method to select the best and most influential parameter ranging and significant through the implementation of a number of experiments that provide us with variable conditions of the parameters, according to Table 2 or L9.

We use Taguchi method in video tracking field is very rare and through the values of S/N ratio, it is clarified for us that the parameter have a positive relationship, such as displacement and speed are converging values and values that are changing where little or weak are S/N values of weak effect.

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