TOLERANCE SPECIFICATION OF ROBOT KINEMATIC PARAMETERS USING OPTIMIZATION METHOD

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Abstract

Designing of kinematic tolerance has become an energetic part in robot kinematic enhancement because of relationship between cost and quality. It is favorite discovered areas in optimization. In this applied work, a investigated Non dominated Genetic Algorithm (NSGA-II), is used for optimizing the tolerance in grounded range on minimum cost the manufacturing cost. The rhino robot assemblies such as planer two link manipulator and five degree-of-freedom considered to demonstrate by the NSGA-II. It is found that the NSGA-II has produced better results than existing Taguchi and monte carlo methods for kinematic tolerance problems.

Keywords: Tolerance, kinematics, optimization and NSGA-II

1. INTRODUCTION

The robotic kinematic tolerance approach seeks a single set of tolerances for the two functions by both design and manufacturing. The kinematic tolerance plays an important role in the reliability of a product assembly guaranteed through accomplishing the assembly reaction to be enclosed in an exact level. Perhaps of tolerance between the dimensions, while total the functionality necessities, is named as design tolerance. Strong tolerances mentioned through engineer promise the recital and actively of the product, whereas engineers check loose tolerances to production parts price successfully. In this work, assembly tolerance problem is considered for industrial manufacturing facilities and also tolerance range in different assemblies. In the literature review, different approaches have been used to solve tolerance problems that are, analytical, Taguchi and ANOVA methods. In the optimization techniques, minimal attention [Roa and Given 1982] investigated to the probabilistic analysis of unclosed loop, exclusively robot kinematic manipulators. Benhabib et al. (1987) developed a direct and inverse robot error analyses. Bhatti and Rao (1988) applied two-link planar was determined analytically, and that of a six Degree of Freedom (DOF) manipulator was determined through the Monte Carlo simulation method. Lindeke and Liou (1989) proposed taguchi for tolerance design an efficient and cost-effective experiment. Kim et al (2010) developed stochastic tool to kinematic consistency of unclosed loop mechanism with tolerance sizes. Ramesh Kumar et al (2016) developed NSGA-II for tolerance optimization problems. Trung e al (2017) presented tolerance design of kinematic Parameters through Generalized Reduced Gradient Algorithm. In this tolerance specification technique robot bit by bit tools a static cause. The special out-turn on the tolerances not considered. In this proposed work NSGA method for kinematic tolerance optimization.

2. MAJOR SOURCES OF ERRORS IN ROBOT MANIPULATORS

In order to obtain robot end effector desired position, a set of joint variables is calculated in robot control. Although, a discrepancy is every time occurs among the original and the desired pose because of the below mentioned source errors.

2.1. Errors (assembly and manufacture)

Because of tolerance error caused during manufacture and assembly, will leads to changes in kinematic robot parameters. Errors are minimized through tightening the tolerances. Though, may increase the manufacturing cost considerably. Next solution of the problem is to determine the novel parameters all the way through applying spotting techniques. Evermore, the spotting method is poisonous and interval tuning. It wants robustly comfortable measurement instrument that is the theo dolite. Errors are named as newly deterministic type errors that is commonly don't change in a robot motion.

2.2. Errors (controllers and actuators)

Due to output of joint link drive fulfillment between bony encoder and genuine angular output, dynamic possessions or supplementary random conflict, is another error is created. These variations can be minimized through locating sensors to react as feedback at the kinematic joints. But, elimination of these errors is not possible because of the declaration of observing and the checker correctness reaction. These errors can be decomposed into 2 parts. Part one is the deterministic special error that is reacts in the equal path, for example being the joint link robot location. The part two in deterministic special error that is random and further considered to trace a ordinary distribution (Gaussian).

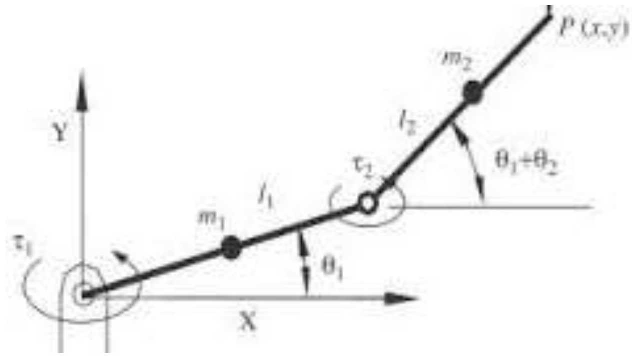

Figure 1 : Position and orientation of robot kinematic linkage

3. METHODOLOGY

3.1 NSGA

Deb et al. (2002) discovered NSGA II method. Commonly, NSGA II changes from NSGA execution in a numerous route. Beginning, NSGA II use top-preserving instrument, henceforth formerly found better results are preserved. Additional, NSGA II applies a quick non dominated sorting procedure. Further, NSGA II algorithm is independent of the user, because it does not require any tunable parameter.

3.1.1 Implementation of NSGA II

A common NSGA II process to be applied in the procedure:

Step 1: The initial parent string is generated randomly, P_t, of size N.

Step 2: Sort the population based on each objective function and obtain the non domination answers.

Step 3: Update the prioritize the non dominated answers grounded on its non domination level ('n' is healthier than 'n+1').

Step 4: Give the children string, Q_t of size, applying the operations that is touranament elected, crossover and additional technique mutation.

Step 5: The actions incorporated in construction of every innovative cycle which are: (a) Joint the couple and kid string to craft the coupling pond of 2 of N. (b) main concern the answers of the welded of size 2 of N using the no one dominated categorization process. (c) select the innovative string, P_{t+1} through preference the handpicked solutions of N grounded on their non domination rank and pack distance size.

(d) Using the elected, crossover and addition mutation technique on the up to date couple string, P_{t+1} to make the innovative kid string, Q_{t+1} of N.

Step 6: Fix and step 5 still the maximum cycles is reached.

3.1.2 NSGA-II operators Parameters of NSGA-II technique are:

Population = 100, the cross over and mutation probability = 0.7 and 0.25, real SBX parameter = 10, real mutation parameter = 100, no of cycles = 100.

4.RESULT AND DISCUSSIONS

The computational result test was purly performed in Pentium IV MS windows 8 and NSGA II was psedo software coded in matlab. The technique were applied to set of kinemat tolerance literature mark problems were available from the literature (Liou et al. 1993). For the kinematic tolerance for two link manipulators, the result gives better results through the implementation of NSGA-II when compared with the Taguchi and Monte Carlo. Table 1, 2 and Figure 1 shows a comparison of NSGA-II with existing results.

Table 1. Results NSGA with existing methods for two-link manipulator (Liou et al 1993)

Case	L1	L2	Θ 1	Θ 2	Monte Corlo	Taguchi	NSGA II
					S/N ratio	S/N ratio	
1	0.015	0.015	0.15	0.15	25.08	25.07	25.06
2	0.015	0.015	0.15	0.30	23.53	23.54	23.52
3	0.015	0.015	0.30	0.15	20.13	20.10	20.09
4	0.015	0.015	0.30	0.30	19.57	19.55	19.54
5	0.015	0.030	0.15	0.15	24.21	24.22	24.21
6	0.015	0.030	0.15	0.30	22.91	22.92	22.91
7	0.015	0.030	0.30	0.15	19.84	19.81	19.80
8	0.015	0.030	0.30	0.30	19.30	19.29	19.27
9	0.030	0.015	0.15	0.15	24.23	24.22	24.21
10	0.030	0.015	0.15	0.30	22.92	22.92	22.92
11	0.030	0.015	0.30	0.15	19.84	19.81	19.80
12	0.030	0.015	0.30	0.30	19.31	19.29	19.28
13	0.030	0.030	0.15	0.15	23.49	23.32	23.31
14	0.030	0.030	0.15	0.30	22.36	22.38	22.36
15	0.030	0.030	0.30	0.15	19.56	19.54	19.53
16	0.030	0.030	0.30	0.30	19.06	19.06	19.05

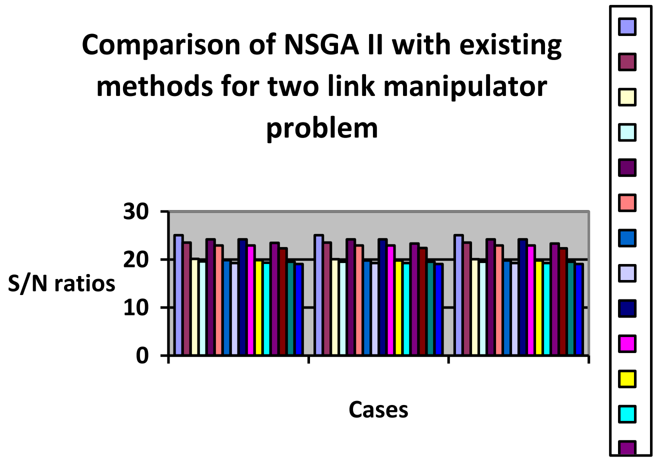

Figure 1: Comparison of NSGA II with existing methods for two link manipulator

Table 2. Comparison of position accuracy between NSGA-II with two methods for Rhino robots

Case	ϴ1	ϴ 2	ϴ 3	ϴ 4	ϴ 5	Monte Corlo S/N ratio	Taguchi S/N ratio	NSGA-II
1	0.05	0.05	0.05	0.05	0.05	37.4663	37.4663	37.4660
2	0.05	0.05	0.05	0.05	0.10	37.4663	37.4663	37.4660
3	0.05	0.05	0.05	0.10	0.05	33.0682	33.0365	33.0361
4	0.05	0.05	0.05	0.10	0.10	33.0682	33.0365	33.0361
5	0.05	0.05	0.10	0.05	0.05	36.8484	36.8348	36.8348
6	0.05	0.05	0.10	0.05	0.10	36.8484	36.8348	36.8348
7	0.05	0.05	0.10	0.10	0.05	32.8284	32.8110	32.8200
8	0.05	0.05	0.10	0.10	0.10	32.8284	32.8110	32.8200
9	0.05	0.10	0.05	0.05	0.05	35.0049	34.9972	34.9972
10	0.05	0.10	0.05	0.05	0.10	35.0049	34.9972	34.9972
11	0.05	0.10	0.05	0.10	0.05	32.0110	31.9812	31.9812
12	0.05	0.10	0.05	0.10	0.10	32.0110	31.9812	31.9812
13	0.05	0.10	0.10	0.05	0.05	34.6443	34.6443	34.6443
14	0.05	0.10	0.10	0.05	0.10	34.6443	34.6443	34.6443
15	0.05	0.10	0.10	0.10	0.05	31.8222	31.7997	31.7997
16	0.05	0.10	0.10	0.10	0.10	31.8222	31.7997	31.7997
17	0.10	0.05	0.05	0.05	0.05	36.2207	36.1881	36.1881
18	0.10	0.05	0.05	0.05	0.10	36.2207	36.1881	36.1881
19	0.10	0.05	0.05	0.10	0.05	32.5735	35.7489	35.7463
20	0.10	0.05	0.05	0.10	0.10	32.5735	35.7489	35.7463
21	0.10	0.05	0.10	0.05	0.05	35.7489	35.7283	35.7245
22	0.10	0.05	0.10	0.05	0.10	35.7489	35.7283	35.7245
23	0.10	0.05	0.10	0.10	0.05	32.3589	32.3318	32.3320
24	0.10	0.05	0.10	0.10	0.10	32.3589	32.3318	32.3320

25	0.10	0.10	0.05	0.05	0.05	34.2551	34.2422	34.2420
26	0.10	0.10	0.05	0.05	0.10	34.2551	34.2422	34.2420
27	0.10	0.10	0.05	0.10	0.05	31.6185	31.5888	31.5880
28	0.10	0.10	0.05	0.10	0.10	31.6185	31.5888	31.5880
29	0.10	0.10	0.10	0.05	0.05	33.9497	33.9414	33.9414
30	0.10	0.10	0.10	0.05	0.10	33.9497	33.9414	33.9414
31	0.10	0.10	0.10	0.10	0.05	31.4457	31.4265	31.4260
32	0.10	0.10	0.10	0.10	0.10	31.4457	31.4265	31.4262

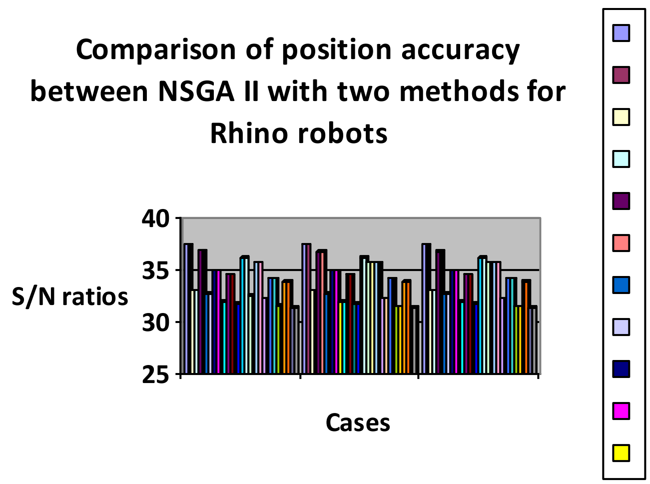

Figure 2. Comparison of position accuracy between NSGA-II with two methods for Rhino robots

Therefore, NSGA II method can reduce the pose error of the kinematic robot by 70 %. The selection of tool is dependent on the needs of the accurate measurement. The computational results provided the basis for an company application of the kinematic robot pose dimension and compensation

5. CONCLUSION

In this paper, a NSGA-II is developed for obtaining the optimal solution for kinematic tolerance allocation problem. The performance of the proposed NSGA-II has been tested with the results presented in the literature (kinematic robotic assembly), and also the main intent of this work has been the implementation of a NSGA-II, for solving the complex assembly tolerance problem. From the computational results, it becomes obvious that the NSGA-II algorithm. Our results show that NSGA-II produces better eminence solutions than existing methods for kinematic tolerance allocation problem in the robot assembly. For future work, the optimal tolerance design can be applied to solve the aircraft and locomotive machine elements; also ANN can be used to solve this type of tolerance problems.

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