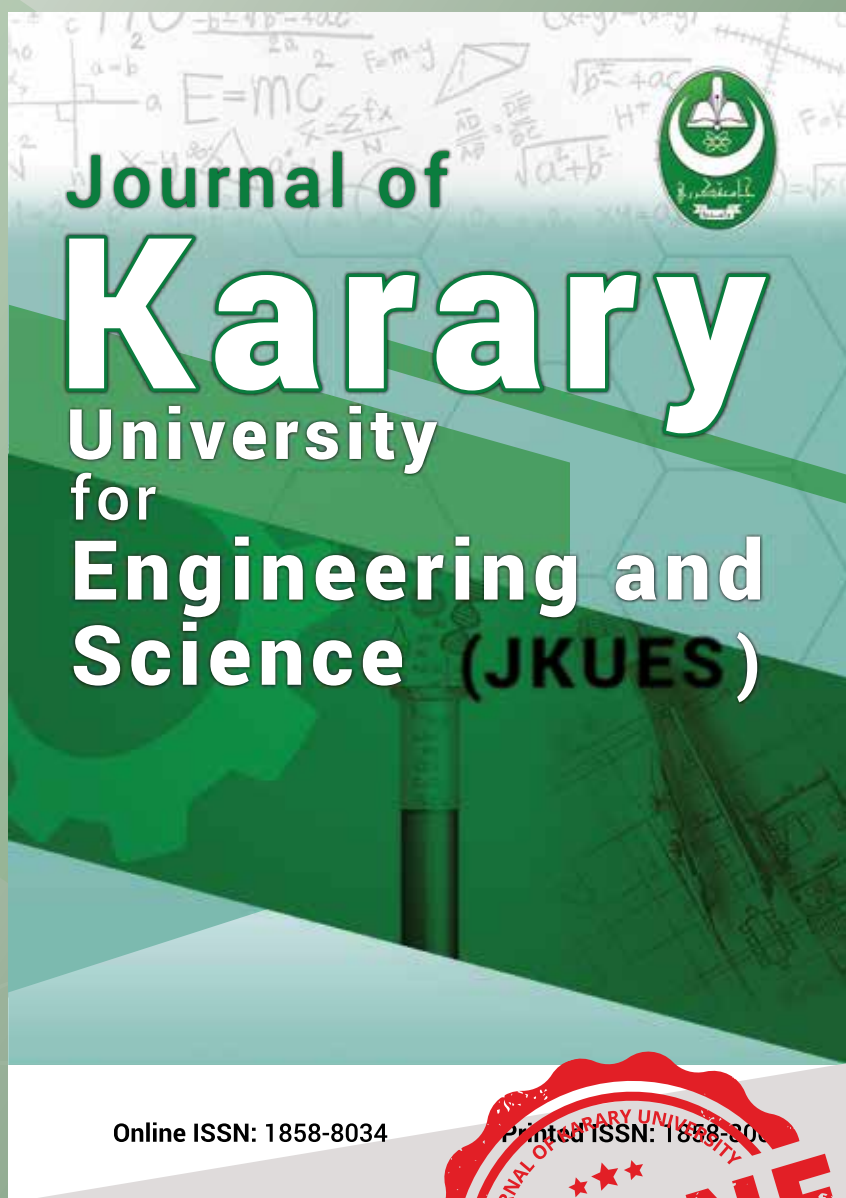


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Dynamic Scheduling of Assembly Line Using Neural Networks for SARIA Industrial Complex-Sudan

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Abstract

In this paper, neural network was developed to improve the dynamic scheduling of SARIA industry complex. This work implemented into two modules: modeling system by time calculation, the main purpose of this modeling is to calculate the total manufacturing times of the products. The second module is the neural network model architecture, constructed to hold a real-time optimization schedule to solve dynamic scheduling problems. Analytical model was built, included collection and manipulation of data, time calculations and the neural networks model was formulated. Several training tests were carried out, then the dynamic scheduling formulated. To assess the validity of the system and to investigate the efficiency and robustness of the system, the results were compared with those obtained from SARIA. The results reveal that the total time of products demand is easy calculated, and the system agile to scheduling any change occur in the demand, also the proposed system reduces 4 shift days for one demand. So the developed neural network leads to minimize the total costs.

Key words-*dynamic scheduling, modeling, assembly line, neural networks*

I. INTRODUCTION

SARIA industrial complex produces more than 60 diversified products, including household appliances, electronic and electrical equipment, footwear, plastic products, garments, car batteries and packaging materials. Dynamic scheduling is the process of absorbing the effect of real-time events analyzing the current status of schedule and automatically modifying the schedule with optimized measures in order to mitigate disruptions [1]. Also dynamic scheduling named (rescheduling) and it is the process of updating an existing production schedule in response to disruptions or other change [2]. Also dynamic scheduling is a direct allocation of tasks to resources, according to given sequencing rules [3].

A dynamic scheduling problem is generally viewed as a collection of linked static problems [4]. Scheduling in manufacturing is an activity of allocating jobs to resources with respect to a time frame that considers critical ratio and considered as N-P hard type of problem [5]. The main problem in job-shop and flexible job-shop scheduling is that of obtaining the best possible schedules with optimal solutions [6]. There is a need to incorporate these dynamic events into the scheduling process, in order to ensure feasibility of the scheduling plan that the manufacturing system is following [7]. Real-time scheduling theory has traditionally focused upon the development of algorithms for feasibility analysis (determining whether all jobs can complete execution by their deadlines) and run-time scheduling (generating schedules at run-time for systems that are deemed to be feasible) of such systems [8], [9], [10]. The problem of scheduling in the presence of real time events, termed dynamic scheduling. Real-time events have been classified into two categories.

A. Resource-related

Machine breakdown, operator illness, unavailability or tool failures, loading limits, delay in the arrival or shortage of materials, defective material (material with wrong specification), etc. Job-related: rush jobs, job cancellation, due date changes, early or late arrival of jobs, change in job priority, changes in job processing time [11][12]. Also [13], [14], [15], [16], [17] in their work agree with that categories. We think that any problem of scheduling in the presence of real-time events, termed dynamic scheduling. Production scheduling at SARIA Industrial Complex formulated in Microsoft Excel, and any problem occurs in the production line "no storing area, maintenance issues" just reported and included with final production report to the planning department. There is no correction actions made, this affects productivity. So this paper aims to minimize the total operation costs of SARIA industry complex..

II. MODEL FORMULATION

The operation data in this study collected from real operation, these data have already been conducted specifically for this study. The model based on two products Freezer GL and Air condition LS, the working hours "line time" $T_{LT} = 9.5$ hours, the time required to assembly the products is:

For GL is $T_{GL} = 17.4$ min

For LS is $T_{LS} = 10.3$ min

The products demand for GL is D_{GL} , and for LS is D_{LS} . The total times to assembly this demand formulated in equations 1, 2.

$$D_{GL} = T_{DGL} = D_{GL} * T_{GL} \quad (1)$$

$$D_{LS} = T_{DLS} = D_{LS} * T_{LS} \quad (2)$$

The total time to assembly both product is

$$T_{DT} = \Sigma T_{DGL} + T_{DLS} \quad (3)$$

The loss in the total time is the maintenance time T_M it is the mean of the intervals of breakdown of the stations in the production line "station availability and breakdowns", the net total production time is T_{NTD}

$$T_{NTD} = T_{DT} - T_M \quad (4)$$

IF $T_{NTD} \leq T_{LT}$ the plan were done and demand produced, but if $T_{NTD} > T_{LT}$ that means we need shift times to produce the demand. Let the time of new demand is T_{NDD} , and the time spends to execute the first demand (per min) is

$$T_{BD1} = T_{NDD} * 5.9 * 60 \quad (5)$$

The time remaining to complete the previous demand is.

$$T_{RD1} = T_{NDT} - T_{BD1} \quad (6)$$

Let the new demand for GL is D_{2GL} and the new demand for LS is D_{2LS} the time required to produce new demand for D_{2GL} is T_{2GL} , and the time required to produce new demand for D_{2LS} is T_{2LS} time required to produce new demand is T_{D2} .

$$T_{D2} = \Sigma T_{D2GL} + T_{D2LS} \quad (7)$$

The available time for produce the new demand can be calculated by the difference between T_{LT} in month and T_{DT} , as formulated in equation 8.

$$T_{AVL} = T_{LT} - T_{DT} \quad (8)$$

IF $T_{D2} \leq T_{AVL}$ the plan were done and the new demand produced, but if $T_{D2} > T_{AVL}$ that means we need shift times to produce the new demand, and the shift times T_{sh} can be formulated in equation 9.

$$T_{sh} = T_{D2} - T_{AVL} \quad (9)$$

Month residual days is M_r which can be formulated in equation 10.

$$M_r = \frac{13680min - T_{DT}}{750min} \quad (10)$$

13680 min is month working time per minutes ($9.5 * 24 * 60$), and 750 min is day working time per minutes ($9.5 * 60$). Then we formulate the shifting days for new demand.

$$D_{sh} = \frac{T_{D2} - T_{AVL}}{750} \quad (11)$$

IF $D_{sh} \leq M_r$ the new demand can be produced in this month, but if $D_{sh} > M_r$ that means we need shift days in next month to produce the new demand. The main purpose of this model is to generate data for neural network model. The purpose of the neural network model is to solve dynamic scheduling problem in SARIA industrial complex which helps in decision making.

III. NEURAL NETWORK MODEL

The networks model structure based on a GUI NN is designed in MATLAB R2017a program, the inputs are operation times from the assembly stations, and outputs mapped as a decision variable take constant values "1, 0, -1", for three decisions "system done, system need shift, this demand cannot be produced in this month" according to the inputs status. The neural network was built using processing times as inputs and outputs of the expected decisions, which makes the system more flexible as possible so that it is suitable for other institutions, but the method is applicable when the data format is changed according to the desired application. The network consists of 2 inputs, 10 hidden layers and one output, which give after the training one of three decisions based on inputs. The weights of the network layers were set in the training process to gives a decision of a robust and adaptable scheduling in and react quickly to unexpected events.

IV. RESULT AND DISCUSSION

The proposed system was built by applying the model formula and use data from Tables I and II

Three tests are performed for three different demands, in each test the updating an existing production schedule is response to disruptions or other change in the factory using the neural network.

To investigate the efficiency and robustness of the system, the results were compared with those obtained from SARIA. The results of these tests are shown in tables III, IV, V, and figures 1, 2, 3.

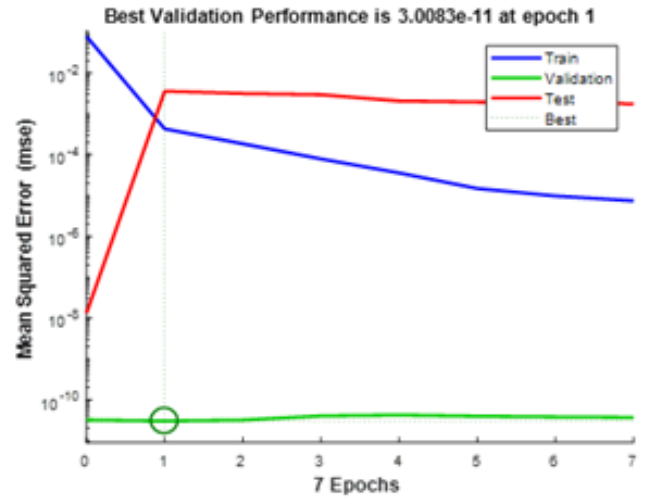


Fig. 1. Train validation performance test for test (1)

The obtained results show that there is a direct relationship between demand and process time as shown in tables III, IV and V. The system was tested using previous years' data, and the results of the outputs of the proposed system are better than those of the basic system, which confirms the effectiveness of the proposed system as shown in tables VI, VII. The proposed system is good and we recommend it to be used in a large number of semi-industrial enterprises, which

TABLE I
DATA FOR FREEZER GL171BML

No. of stations	1	2	3	4	5	6	7	8	9	10
No. of operations in the station	7	1	4	5	6	2	4	4	5	2
operations processing time per mints	1.8	1.4	1.9	2	2.5	0.6	1.2	2.5	1.5	2.1

TABLE II
DATA FOR AIR-CONDITION LSUC186C8U1

No. of stations	1	2	3	4	5	6	7	8	9	10
No. of operations in the station	2	2	2	2	2	2	1	2	2	1
operations processing time per mints	1.1	0.5	1	1.5	2	1	0.25	0.2	1	0.5

TABLE III
TIMES PARAMETERS VALUES FOR TEST (1)

Value per min	Times	No.
1.0162*104	For first demand	1
4162	For second demand	2
5.60117*103	Residual time for first demand	3
9.7671*103	Total time for all demands	4

TABLE IV
TIMES PARAMETERS VALUES FOR TEST (2)

Value per min	Times	No.
1.3206*103	For first demand	1
7.6700*103	For second demand	2
6.9357*103	Residual time for first demand	3
1.4606*103	Total time for all demands	4
5 days	Shifts days	5
13 days	Month residual days	6

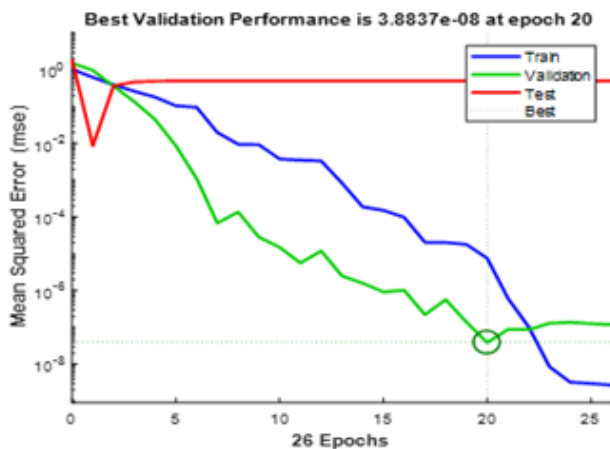


Fig. 2. Train validation performance test for test (2)

will increase the national industrial production and contribute to economic growth

V. CONCLUSION

In this work, a dynamic scheduling problem was defined, the model was formulated by time calculations, and the data was

TABLE V
TIMES PARAMETERS VALUES FOR TEST (3)

Value per min	Times	No.
1.958*104	For first demand	1
9739	For second demand	2
9.3241*103	Residual time for first demand	3
1.9063*104	Total time for all demands	4
13 days	Shifts days	5
6 days	Month residual days	6

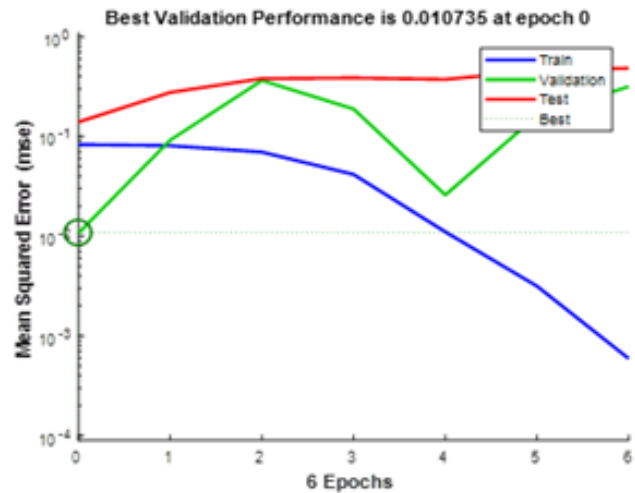


Fig. 3. Train validation performance test for test (3)

collected and manipulated. By using neural network graphical user interface in MATLAB R2017 program the model was verified, the pc used with Intel core i7 processor and 4GB RAM, dynamic scheduling was done, and the validity of

TABLE VI
RESULTS OF OPERATION TESTS AT THE INDUSTRIAL COMPLEX

Operation No.	GL1	LS1	GL2	LS2	Decision making
1	1000	0	0	0	6 days in next month
2	380	380	0	0	Demands Produced
3	477	219	0	521	4 days in next month

TABLE VII
RESULTS OBTAINED FROM THE SYSTEM

Operation No.	GL1	LS1	GL2	LS2	Decision making
1	1000	0	0	0	4 days Shift
2	380	380	0	0	Demands Produced
3	477	219	0	521	2 days Shift

the proposed system has been implemented. The dynamic scheduling for the SARIA was solved for tow parameters, new an unexpected demand and the second parameter is the maintenance time. The maintenance time was included in the time calculations as a fixed value. Increasing in demand lead to increasing in time, then rescheduling is required to make new decision. When a new demand is entered, the system made quick and accurate rescheduling, which reduces production costs and drives the national economy. The research objectives were achieved through the use of neural networks. This work can be further extended by using an application of artificial intelligence for making quick on line decision.

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