An Entropy Based Group Setup Strategy for PCB Assembly

In-Jae Jeong

Department of Industrial Engineering, Hanyang University,
Seoul, 133-791, South Korea
ijeong@hanyang.ac.kr

Abstract. Group setup strategy exploits the PCB similarity in forming the families of boards to minimize makespan that is composed of two attributes, the setup time and the placement time. The component similarity of boards in families reduces the setup time between families meanwhile, the geometric similarity reduces the placement time of boards within families. Current group setup strategy considers the component similarity and the geometric similarity by giving equal weights or by considering each similarity sequentially. In this paper, we propose an improved group setup strategy which combines component similarity and geometric similarity simultaneously. The entropy method is used to determine the weight of each similarity by capturing the importance of each similarity in different production environments. Test results show that the entropy based group setup strategy outperforms existing group setup strategies.

Keywords: Printed circuit board assembly, group setup, entropy method, similarity coefficient.

1 Introduction

This paper considers a group setup problem in a single SMT machine producing multiple types of boards. The head starts from a given home position, moves to feeder carriage on the machine to pick up the component. After picking up the component, the head moves to the placement location on the PCB for this component. Then the component is placed on the board and the head travel back to the feeder carriage to pick up the next component. The pick-and-place process continues until all components required for the board have been completed.

Let K be the total number of family and N_f be the number of boards in family f. Then the total number of boards,$N = \sum_{f=1}^{K} N_f$. We assume that the head velocity, v(mm/sec) and the feeder installation/removal time,σ are constant for all types of boards. Also, let m_f be the number of feeder changes required from family $f-1$ to f and d_i be the length of tour followed by the head to assemble board i. b_i is the batch size of board i. Leon and Peters (1996) proposed the following conceptual formulation of the group setup problem:

M. Gavrilova et al. (Eds.): ICCSA 2006, LNCS 3982, pp. 698–707, 2006.

Minimize: Makespan=$\sum_{f=1}^{K}(\sigma m_f + \sum_{i=1}^{N_f} \frac{b_i}{v} d_i)$
Subject to: Feeder capacity constraints
Component-feeder constraints
Component placement constraints

The objective is to minimize the makespan for producing multiple types of boards. The first term of the makespan is the setup time to remove the previous setups and install components on feeders for current family. The second term is the time to place all components on all boards in a batch for current family. If all boards are grouped as a single family, the setup will occur only once minimizing setup time. However, the single family solution will increase the total placement time since the common setup is not prepared for individual boards. On the other hand, if all boards form a unique family of its own, the placement time reduction will be surpassed by setup time. Hence, boards must be grouped such that within the family, boards share as many common component types as possible (i.e., component similarity) in order to reduce setup time between families. Also the placement locations of boards within the family must be similar to each others (i.e., geometric similarity) in order to reduce placement time. Therefore the development of good similarity coefficient is important issue in a group setup strategy.

The decision variables are the number of family K, the types of boards in family f, N_f and the placement sequence of locations in board i and the component-feeder assignment for family f to determine d_i.

The first constraints represent the feeder capacity constraints. Total number of different component types in any family can not exceed the feeder capacity since only one component type can reside in one feeder slot. The second constraints, component-feeder constraints means that each component needed for boards in a family must be assigned to a feeder. The third constraints, component placement constraints are equivalent to traveling salesman problem (TSP) constraints. That is, the placement head must visit all the placement locations on a board. The distance between two placement locations is the time for the head to move from the first placement location to the feeder slot containing component for the second placement then to the second placement location.

Existing group setup strategies (1)considers component similarity only (Leon and Peter 1998) or (2) forms families of boards based on geometric similarity and select the groups of boards based on component similarity in sequential manner (Leon and Jeong 2005) or (3) considers an overall board's similarity coefficient which combines component similarity and geometric measure by assigning equal weights(Quintana and Leon 1999). Leon and Jeong (2005) reported that the performance of group setup strategy of case (2) performs better than other cases.

The motivation of this paper was the belief that the determining appropriate weights of case (3) and combining both similarities simultaneously could achieve a further reduction of makespan . Combining different criteria into a synthesized criterion falls into a well known research area, Multiple Criteria Decision Making (MCDM). In this paper, we use the entropy method for calibrating the weights assigned to the component similarity and the geometric similarity. The entropy