Parallel data processing for PCB testing

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PCBs (Printed Circuit Board) inspection and testing requires an analysis of some performance criteria for the data acquisition and processing system. These criteria are determined by the physical properties of the processes, which determine the concurrent propagation of the signals in the PCBs [1] and requires their acquisition and parallel processing [2]. In this case it is necessary to apply the methods and models of concurrent processing of multidimensional digital signals [3].
The major issue in the development of PCB testing systems is the spatial and time synchronization of data acquisition and processing [1, 2]. This problem can be solved by developing new discretization and signal acquisition methods and new mathematical models for their processing.
Let‘s consider the PCB board with a set of input signals $\boldsymbol{U}^{\text{In}}$ and a set of output signals $\boldsymbol{U}^{\text{Out}}$, where: $\boldsymbol{U}^{\text{In}} = u_i^{\text{In}}, i = \overline{1, N}$ with N test input points; and $\boldsymbol{U}^{\text{Out}} = u_j^{\text{Out}}, j = \overline{1, K}$ with K measuring test points. The mathematical model for measured test signals calculation according to the input test signals $\boldsymbol{U}^{\text{In}}$ and the electrical parameters $\boldsymbol{Z}_j$ of the PCB is described by the following formula:

$$u_j^{\text{Out}} = g_j\left(\boldsymbol{U}^{\text{In}}, \boldsymbol{Z}_j\right).$$

The functional scheme for the PCB testing system consists of a test signal generator $\boldsymbol{U}^{\text{In}}$ (designed on an FPGA circuit), a device for the injection of $\boldsymbol{U}^{\text{In}}$ signals on the PCB and for obtaining the measured signals $\boldsymbol{U}^{\text{Out}}$ from the PCB. The identification of the measured signals shape $\boldsymbol{U}^{\text{Out}}$ is done by their differentiation $\dfrac{\mathrm{d}u_j^{\text{Out}}}{\mathrm{d}t}$ and further integration $\displaystyle\int_0^T \left(\dot{u}_j^{\text{Out}}\right) \mathrm{d}t$. The differentiation function is performed on a variety of electronic differentiation and fuzzy circuits, the result of which is stored and transmitted to a computer. Parameter testing of the PCB takes place on the PC as a result of the analysis of the influence of the input signals $\boldsymbol{U}^{\text{In}}$ on the output signals $\boldsymbol{U}^{\text{Out}}$:

$$\frac{\partial u_j^{\text{Out}}}{\partial u_i^{\text{In}}}, i = \overline{1, N}, j = \overline{1, K}$$

and the mutual inflection of the output signals $\boldsymbol{U}^{\text{Out}}$:

$$\frac{\partial u_j^{\text{Out}}}{\partial u_l^{\text{Out}}}, l = \overline{1, K}, j = \overline{1, K}.$$

Functional modeling and interaction of parallel data processing system components for PCB testing was performed on the basis of UML diagrams.

Bibliography

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Parallel algorithm to determine the Nash solutions in bimatrix games

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Given a bi-matrix game $\Gamma = \langle I, J, A, B\rangle$ where I – the row index set of the matrix, J – the column index set of the matrix, $||a_{ij}||_{i\in I}^{j\in J}$ and $||b_{ij}||_{i\in I}^{j\in J}$ are the playersâ€™ payoff matrices. We construct the following parallel algorithm to determinate equilibrium profiles.

1) Data parallelization. The MPI process with rank 0 initializes matrices A and B, then distributes, based on the 2D cyclic algorithm, the sub-matrices obtained by each MPI process from the virtual 2-dimensional topology communicator.Thus, each MPI process will only work with sub-matrices obtained as a result of distribution.

2) Each process from the virtual 2-dimensional topology communicator will eliminate, in parallel, from the sub-matrices of the matrices A and B that it possesses based on the step 1), those rows that are dominated in matrix A and those columns that are dominated in matrix B.

3) Determination of the equilibrium strategies for the matrix (A', B'), $A' = \left\|a'_{ij}\right\| \begin{matrix} i \in I' \\ j \in J' \end{matrix}$ and $B' = \left\|b'_{ij}\right\| \begin{matrix} i \in I' \\ j \in J' \end{matrix}$ obtained in step 2). It's clear that $|I'| \le |I|$ and $|J'| \le |J|$. For this using the reduction operations, each process will determine $i^*(j) = \arg\max_{i\in I'} a'_{ij}$ for any $j \in J'$ and $j^*(i) = \arg\max_{j\in J'} b'_{ij}$ for any $i \in I'$.

4) We select those index pairs that are simultaneously selected in both matrix A' and matrix B'. In other words, it is determined $\begin{cases} i^* \equiv i^*(j^*) \\ j^* \equiv j^*(i^*) \end{cases}$ which is actually the intersection of the graphs of the following point to set applications $i^*(\cdot)$ and $j^*(\cdot)$.

5) The equilibrium strategies for the game with the initial matrices A and B are built.