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An intelligent system for tuning magnetic field of a cathode ray tube deflection yoke

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Abstract

This short communication concerns identification of the number of magnetic correction shunts and their positions for deflection yoke tuning to correct the misconvergence of colours of a cathode ray tube. The misconvergence of colours is characterised by the distances measured between the traces of red and blue beams. The method proposed consists of two phases, namely, learning and optimisation. In the learning phase, the radial basis function neural network is trained to learn a mapping: *correction shunt position* → *changes in misconvergence*. In the optimisation phase, the trained neural network is used to predict changes in misconvergence depending on a correction shunt position. An optimisation procedure based on the predictions returned by the neural net is then executed in order to find the minimal number of correction shunts needed and their positions. During the experimental investigations, 98% of the deflection yokes analysed have been tuned successfully using the technique proposed.

Keywords: Cathode ray tube; Learning; Neural network; Simulated annealing

1. Introduction

This short communication concerns the use of image analysis and neural networks based techniques for tuning magnetic field of a deflection yoke of a cathode ray tube (CRT). Several prototypes of the system have been installed in the 'Vilniaus Vingis' company, Lithuania, and are successfully used on production line.

The most widely used display device for television and computer monitors is the colour Cathode Ray Tube [1]. In the colour CRT, three electron guns producing three beams of electrons hitting three colour phosphors are used. The red (R), green (G), and blue (B) phosphors are placed on the inner part of a TV screen as dots or strips. In order to create a picture on a TV screen, the beams are scanned across the screen by electromagnetic deflection mechanisms. A deflection yoke of the CRT supplying the vertical and horizontal magnetic fields enables the scanning process. If the magnetic fields are not correctly formed, the misconvergence of the three beams may occur. The misconvergence is characterised by the actual distances measured on a TV screen between traces of the three electron beams when the distances are supposed to be zero. The misconvergence of the beams causes the misconvergence (mismatch) of the red, green, and blue components of a picture displayed on a TV screen (misconvergence of colours). The misconvergence is eliminated by sticking one or several magnetic shunts on the inner part of DY, as shown in Fig. 1. The tuning is usually done manually by human experts. Manual tuning is a very tedious and time-consuming procedure. Moreover, the tuning quality depends heavily upon the expert's experience, tiredness, and other factors.

2. Tuning approach

The misconvergence of colours is evaluated by measuring distances R–B, R–G, and B–G between the beam traces of the three primary colours R, G, and B of the same

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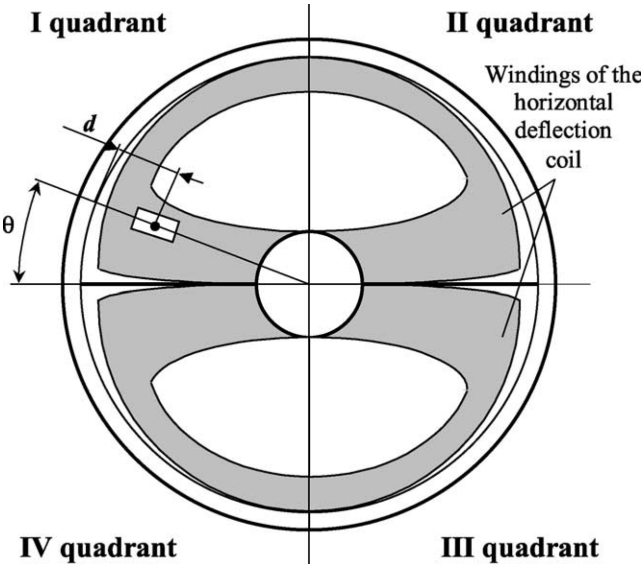

Fig. 1. The inner surface of the DY with a correction shunt.

picture element. The manufacturing accuracy of DYs is high enough to assume that the trace created by the green beam is always in between the traces created by the red and blue beams. Therefore, the misconvergence of only the red and blue beams is considered. Hence, the only parameters used to characterise the misconvergence in some *i*th point of the image are $x_i^{RB} = x_i^R - x_i^B$ and $y_i^{RB} = y_i^R - y_i^B$. For the DY adjustment purpose we measure the misconvergence in nine ($i = 1,\ldots,9$) beforehand chosen control positions, as shown in Fig. 2. The DY being adjusted is placed on a CRT and a grid test pattern, consisting of three vertical and three horizontal lines, crossing each other in these control positions, as shown in Fig. 2, is generated on the screen of the CRT. The nine intersection points of the green, red, and blue components of the test pattern are the elements of the pattern used to measure the colour misconvergence. The aim of tuning is to eliminate the misconvergence of colours by sticking one or several magnetic shunts on the inner part of a deflection yoke. To achieve the goal a method for identifying the number of correction shunts and their positions has been developed. The method consists of two phases, learning and optimisation.

In the learning phase, the radial basis function neural network [2] is trained to perform a mapping: *correction shunt position* → *changes in misconvergence*. The position is given by a distance *d*, as measured from the outermost border of a DY, and an angle θ, as measured from the horizontal axis (Fig. 1). As it was already discussed, the misconvergence is evaluated in nine points of the screen by measuring the distances $x_i^{RB} = x_i^R - x_i^B$ and $y_i^{RB} = y_i^R - y_i^B$. Therefore, we are left with $18(9 \times 2)$ 'primary' parameters $x_1, \ldots, x_9, y_1, \ldots, y_9$, were the indices refer to the control positions. Hence, in the learning phase, the neural network performs a mapping from the shunt position space, defined by a depth and an angle, to the space of misconvergence changes $\delta_{x1}, \ldots, \delta_{y9}$.

In the optimisation (operating) phase, the actual beam misconvergences $x_1, \ldots, x_9$ and $y_1, \ldots, y_9$ are measured. If at least one of the measurements is outside of the allowable interval, the tuning process is activated. First, employing the learned mapping, the changes in misconvergence are predicted for the different correction shunt positions. Having the neural network's prediction results for all the correction shunt positions the number of shunts and their

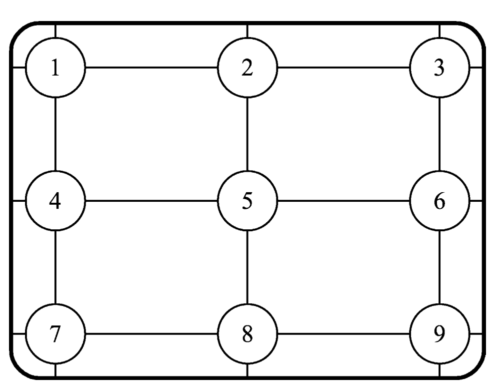

Fig. 2. Control positions and the test pattern on the screen of the CRT.