

# Colourmap™

## the absolute XYA scale

**Colourmap™ dot scale technology is a patented, absolute XY and angle scale system. A matrix of coloured dots is used to encode both X and Y positions. At any position on the scale the pattern of coloured dots will be unique, allowing X and Y positions and the angle of the sensor to be calculated. Because the angle of the sensor is also measured, there is no need to constrain the moving element orthogonally. This means that the system could potentially revolutionise current thinking with regard to applications that require two-dimensional measurements.**

• **Gavin Bailey** •

The idea for a two-dimensional scale came directly as a result of work designing three-dimensional co-ordinate measuring machines (CMMs), which are the core product of Aberlink's business. On CMMs each axis will contain its own independent linear scale, and then to achieve accuracy each axis must be controlled so that its motion is perpendicular to each of the other axes.

The Colourmap scale system provides a method for measuring both X and Y position and angle. This not only eliminates the requirement for two sets of linear scales, but also overcomes the need for the axes to run orthogonally to each other. The sensor can be a simple CCD/CMOS Camera. This moves over and reads a pattern of coloured dots. For each position throughout the range of the scale, the pattern of coloured dots will be unique, from this information, the scale can determine not only the X and Y position of the sensor, but also determine the angular position of the sensor relative to the dots on the scale; see Figure 1.

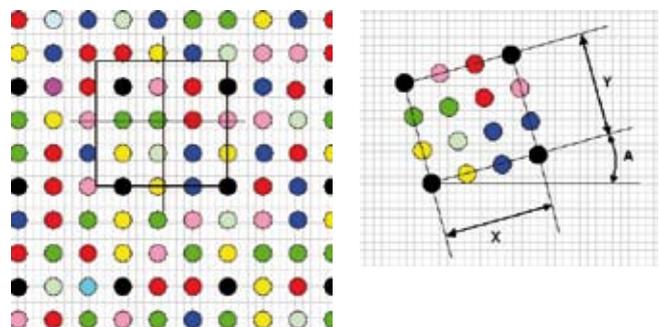


Figure 1. The principle of the Colourmap scale system is that of a sensor looking at a pattern of coloured dots that is unique at each position throughout the scale. This allows the determination of not only the X and Y position, but also the angular position of the sensor relative to the dots on the scale.



Figure 2. Project X is the vision machine that is the first application for the Colourmap scale system.

An important feature of the Colourmap scale system is that it provides an absolute XYA scale. Regardless of whether the scale misses a reading, which may be due to incomplete/damaged scale, excessive speed of movement, power failure or any other reason, as soon as the sensor receives a valid reading from the scale, it will know its X, Y and A position. This means that no reference marks are required.

Coloured dots were chosen as the scale indicators because it is simple for a CCD/CMOS camera to differentiate between colours, although equally any other type of identifiable object or shape could be used to provide the same results.

### Applications

Because Aberlink is a metrology company, the first idea for an application of the Colourmap scale system was as the scale within a measuring machine. This lent itself ideally to a vision machine, where the sensor for the measuring instrument was also a camera, and therefore the measurements performed are two-dimensional. The 'Project X' vision machine, which incorporates the Colourmap scale system, is described in detail below. However, the exciting

fact about the scale system is that it is completely scaleable. Using standard interpolation techniques the centre position of each dot can be determined to a small fraction of the camera pixel size. Typically the distance between dots can be resolved to around one thousandth of their pitch. Hence the scale system could equally be used on a high precision stage with microscope optics to give a resolution of nanometres, or on an Automatic Guided Vehicle (AGV) with low-cost optics to give a resolution of millimetres.

Because the Colourmap scale is absolute, should such an AGV lose its position temporarily, there would be no need for it to be returned to its docking station in order to regain its position. Moreover, because the angle is calculated, the vehicle heading is always known even when stationary.

### The 'Project X' vision machine

Project X is a revolutionary 2D vision measuring machine, and was the first application that used the Colourmap scale system; see Figure 2. Because it was important not to disclose the technology to any third party until the worldwide patent for the scale system had been filed, during its development the machine was referred to as 'Project X'. Then, when a name for the released product was eventually required, this sobriquet was retained.

Within the measuring machine a 'C' shaped bracket is used to float over the Colourmap scale system on an air bearing system. The scale camera is mounted directly below the measurement camera, as in the arrangement shown in Figure 3.

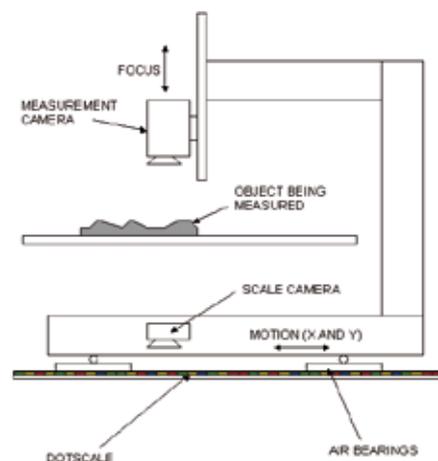
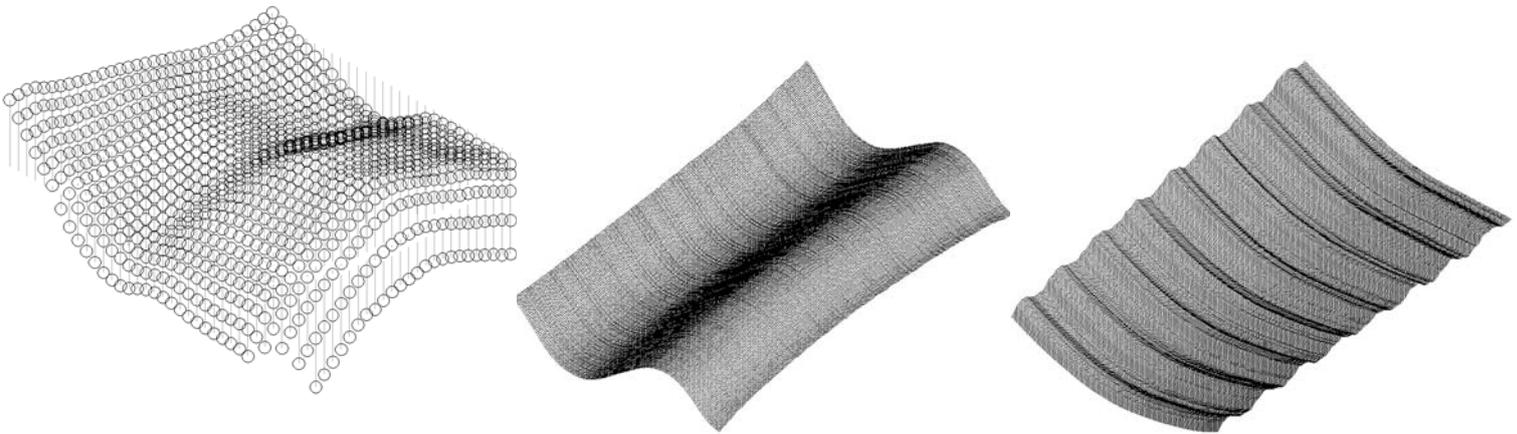


Figure 3. The Project X 2D vision measuring machine as it is equipped with the Colourmap scale system.



(a) Flatness of glass plate.

(b) Error of dots in X direction.

(c) Error of dots in Y direction.

Figure 4. Calibration of a Colourmap scale.

The scale, which covers an area of 400 x 300 mm, is printed simply using a high quality laser printer onto photographic paper. The dots have a nominal diameter of 0.25 mm on a pitch of 0.5 mm. The photographic paper is then bonded in clear epoxy between two sheets of float glass. The glass then acts as a perfectly smooth, flat and clear surface for the assembly to float over using an air bearing system, allowing the scale camera to read the pattern of coloured dots.

By looking at just nine dots and using seven different colours, over forty million different permutations are possible. By looking at more dots, redundancy is built into the system, ensuring that it is robust against any difficulty in identifying individual dots due to damage or colour fade, etc.

Project X makes use of the Colourmap scale system not only to get absolute X and Y position, but also because the scale measures the angular position of the encoder. This means that the mechanical assembly described above does not have to be constrained along each axis. If the assembly rotates, then the scale reports the angle. Therefore the 'C' shaped frame is simply guided around the scale by a set of pulleys and cables, without the requirement for expensive guideways.

Because the Project X has an accuracy requirement greater than the repeatability of the printing of the dot pattern, each scale must be individually measured in order to produce an error map of the dot positions, which can then be easily applied to any measurements reported by the scale. This is performed on a special-purpose measuring machine, which is able to obtain the results shown in Figure 4.

The measurement camera on Project X is then used to view the component to be measured, and its image analysed to produce dimensions. The scale system is required when the

measurement camera has to be moved because the component is larger than the field of view of the camera.

The software written for Project X is a comprehensive vision package that offers a full range of automatic edge detection. The measurement camera is mounted on a motorised Z-axis that offers 125 mm of motion to provide auto-focussing on a wide range of different sized components. Also Project X can be supplied with the X and Y motion either under manual or full CNC control.

### Future potential

So far the Colourmap scale system has only been used in a metrology application. However, the potential to revolutionise two-dimensional measurement is even more exciting than the innovative and inexpensive measuring machine described above. It is a technology looking to find new applications in other industries away from metrology. Precision stages and AGVs have already been mentioned, but pick & place machines in the electronics industry also require exactly the same feedback.

### Author's note

Gavin Bailey is Sales Director and co-founder of Aberlink, the largest UK-owned manufacturer of co-ordinate measuring machines, based in Eastcombe, Gloucestershire, UK. The Colourmap™ scale system is the invention of Marcus Eales, Technical Director and co-founder of Aberlink. Eales formerly worked at Renishaw, the UK-based, high-tech metrology company.

### Information

[www.aberlink.co.uk](http://www.aberlink.co.uk)