EasyBlend™
Automatic Digital Image Calibration

Technology and Applications
Automatic Digital Image Calibration

Scalable Display Technologies’ (SDT) new image calibration and edge-blending solution introduces camera feedback for automatic digital-image correction. The EasyBlend™ solution replaces expensive mechanical alignment of multiple projector configurations with software that automatically adjusts and corrects projected images on the most demanding of surfaces.

With patented automatic image-correction software, SDT brings feedback and digital-image processing to a broad range of commercial and consumer projection markets. This solution lowers the cost of generating and calibrating high quality images — and offers innovative and unique technical opportunities.

Relying on feedback from a digital optical-input sensor or camera, SDT’s EasyBlend software automatically calibrates the geometry, color, and intensity of images produced by multiple projector systems. The technique offers significant advantages in single projector systems as well.
EasyBlend technology: Optical feedback

Now low-cost computation coupled with camera-driven feedback can compensate for the misalignments, optical imperfections, and fabrication shortcuts found in many commercial optical products today. EasyBlend uses camera feedback of an image array to correct for image warping, correct color, and blend images. This entirely digital, scalable technology produces displays that are bright, high resolution, portable, and self-calibrating. Using SDT’s technology, project a single seamless wall of overlapping images. Our purely digital approach allows you to create displays that simply can’t be engineered by conventional mechanical or optical means.

Camera feedback and digital image processing using SDT’s EasyBlend software produces the highest-quality image for the lowest price. Replace costly labor-based precision and optical skill with inexpensive digital image processing. SDT algorithms will automatically:

- Provide soft edge blending for seamless tiling of images from multiple projectors, even when positioned at odd angles
- Correct for spatial optical distortion
- Adjust for image warping on flat, cylindrical, spherical, and arbitrary surfaces
- Ensure uniformity by matching intensity and color across an image generated from multiple projectors
- Correct color across an image
- Scale content to fit screen size
- Detect screen frame or allow for manual specifications
- Compensate for projector-lamp brightness and color degradation, ensuring color temperature and uniformity are maintained over time
- Work with available external warping hardware
System architecture: Low price and scalability

EasyBlend system architecture is composed of two phases: calibration and display. The primary input to the calibration phase is feedback data from a camera set up to observe the entire image, whether from a single or multiple projectors. Calibration output from this camera is fed to the display phase.

**Calibration phase**

**Measure and compute positional warp:**
Test charts and test projections are used to derive positional mappings between each projector and the screen, and also between the screen and the camera. These mappings pinpoint the exact location on the screen of each pixel from each projector.

**Measure and compute intensity and color warp:**
Feedback data from the camera are added to the positional mappings to correct color and intensity across the image.
**Display phase**

The calibration phase generates a two-dimensional lookup table, used by the image warper to correct projector outputs. The computer applies digital image warping to the image in its frame buffer and outputs appropriately pre-distorted projector input signals. The result is a seamless and geometrically correct image across the entire projector field.

Taking image feedback from the camera, the computer uses digital image processing techniques to compensate for visible imperfections, including:

- Perspective distortions, causing trapezoid-shaped projections
- Pincushion and barrel distortions from the optics, resulting in projection bowing outward and inward
- Alignment distortions between projectors, resulting in misalignment in the overlap regions
- Intensity and color distortions caused by different projectors with varying light sources and optics, plus overlapping regions illuminated by multiple projectors

The 2D lookup table contains parameters to compensate for all of these distortions, remapping the position and intensity of each pixel to display a seamless image. Positional remapping enables the display of straight lines across the projection array, limiting the total displayed image to the largest rectangular region covered by the array of projected images.

**Off-the-shelf silicon elements**

The EasyBlend solution capitalizes on the ubiquitous availability of four low-priced, off-the-shelf silicon elements:

- Microdisplay silicon for projection
- FPGA/ASIC/GPU silicon for warping
- CMOS/CCD sensors to provide image feedback
- Microprocessor for process control
**Broad range of commercial and consumer applications**

The EasyBlend solution from Scalable Display Technologies has numerous commercial and consumer applications in both multi-projector and single projector environments.

**Multiple projectors: Edge-blended and stacked display on any surface**

With SDT’s purely digital approach to autocalibration and edge blending, it is easy to set up multiple projectors for innovative displays with higher intensities and higher resolution — at lower equipment and labor costs. Other multi-projector installations on the market today are typically aligned by hand, a painstaking and costly process that usually takes several hours per projector.

Multi-projector displays that eliminate the need for expensive on-site technical support are now an increasingly versatile alternative for auditoriums, tradeshows, entertainment venues, conference rooms, simulation facilities, immersive videoconferencing, and museums without the need for expensive on-site technical support. EasyBlend technology also improves the quality of rear projection video walls and makes possible the engineering of very large curved monitors.
First application — SDT Multi-Projector System

SDT’s first application of automatic feedback image correction was to implement a Multi-Projector System for displays with increased brightness and resolution that will automatically re-calibrate to maintain the quality of the image.

Our system produces dramatically superior images at considerably lower life cycle costs. With our system event staging, digital signage and simulation companies can:

- Create extremely large, high-end, innovative displays with consistent high brightness and resolution
- Project top-quality displays onto narrow and complex surfaces previously unusable for technical or financial reasons
- Shorten setup lead times and minimize display downtime due to hardware malfunction
- Radically reduce the life cycle cost of hardware and labor while increasing image quality

Refer to SDT’s MULTI-PROJECTOR SYSTEM product brochure for more details.

Display Examples

- Use four 5,000 lumen projectors to create a 20,000 lumen display, achieving almost 4 times the resolution of the 5,000 lumen projector
- Implement 10-megapixel monitors for professional graphics and engineering workstations
- Create digital wallpaper with extreme resolution
- Build affordable gigapixel displays for simulation/virtual reality
- Set up projectors at odd angles and automatically calibrate to ensure a smooth image
Thin Rear Multi-Projector Video Walls with Ultrahigh Resolution Displays

Until recently, video walls were built with modules. Unfortunately the thin spaces between the modules were easily visible, resulting in a “window pane” effect. Current video wall designs are built with multiple rear projection equipment. This produces large seamless displays, but this design requires frequent mechanical alignment and color calibration in order to maintain image quality. Without frequent realignment, the slight color and intensity differences among the individual projectors are easily discernable.

Because of the tedious mechanical alignment difficulties, video walls that use rear projection typically employ no more than four projectors. However, using a larger number of smaller projectors allows the construction of video walls that are bigger and desirably thinner.

Many video walls in public spaces like transportation facilities and department stores employ video walls that are 20 feet x 20 feet and larger. Such large systems are usually modular and consist of 10 or 20 video modules. While it is feasible to construct mechanically aligned systems with 10 or 20 projectors, it is certainly not convenient. EasyBlend eliminates the mechanical alignment and calibration process.

EasyBlend provides two key advantages in setting up and maintaining video walls:

1. Use tilable, overlapping projectors which remove the “window pane” effect and create giant seamless displays.

2. Keep separate modules balanced in color and intensity, maintaining a high quality image — without the need for a technician.
Rear Multi-Projectors for High Resolution, Very Large Curved Monitor

This same autocalibration technique can be used for very high resolution, very large desktop monitors. In the mockup of a large curved desktop monitor, below, microprojectors are mounted behind the display surface. As an example, 24 microprojectors could be used to cover the entire screen. If each microprojector had a resolution of 1024 x 768, then the 24-projector array would easily provide 16 megapixels of resolution.

A high resolution, very large desktop monitor is the ideal solution for engineers, traders, designers and architects who need to view multiple simultaneous computer screen images.
Single-Projector Systems
Rear-Projection TVs, Front Projectors

SDT EasyBlend calibration technology has significant application in the fast-growing rear-projection TV (RPTV) and front projector TV market where digital imaging is critical. By incorporating SDT’s EasyBlend automatic calibration software into their systems, TV and projector manufacturers will benefit in important ways:

Reduce cost of materials while improving image quality

- Lower cost and increase manufacturer yields by using less expensive lenses, corrected for chromatic aberration and brightness uniformity by our autocalibration software
- Use computation and feedback to replace expensive optics and allow use of cheaper mirror materials for thinner systems

Eliminate color miscalibration

Build user-friendly automatic color calibration into the projector and:

- Automatically color calibrate the equipment in the showroom for optimal image quality
- Offer consumers the ability to calibrate their system at home, without a technician:
  - Correct for lateral color
  - Eliminate color miscalibration due to bulb drift or environmental factors
  - Automatically correct for keystone
Consumers can automatically calibrate RPTV and front projector TV color at home with the push of a button.

Thinner RPTV at lower prices with optimal image quality.
About the Company

Scalable Display Technologies, Inc. was founded in 2004 to commercialize technology developed and patented by MIT. Our EasyBlend™ software solution relies on camera-generated feedback for automatic calibration and edge blending of multiple projectors, eliminating the need for painstaking and time-consuming mechanical pointing of projectors. This purely digital approach creates display systems that cannot be engineered by conventional means, either mechanically or optically. The result is brilliant high-intensity, high-resolution images from digital projectors at very reasonable costs.