Improved Projector Functions Based on System Linkage with PC

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Abstract

Projectors that offer adaptability of installation in any location and projection on any screen shape improve not only the degree of freedom of usage but also give users more choice of visual expression. In order to respond to this viewpoint, NEC Display Solutions has provided high-class projector models with the geometric distortion correction function since the dawn of business projector production. Recently, the company has succeeded in implementing geometric distortion correction in a system linked to a PC in order to make use of its computing function. The present paper describes how the system is packaged in low-priced models.

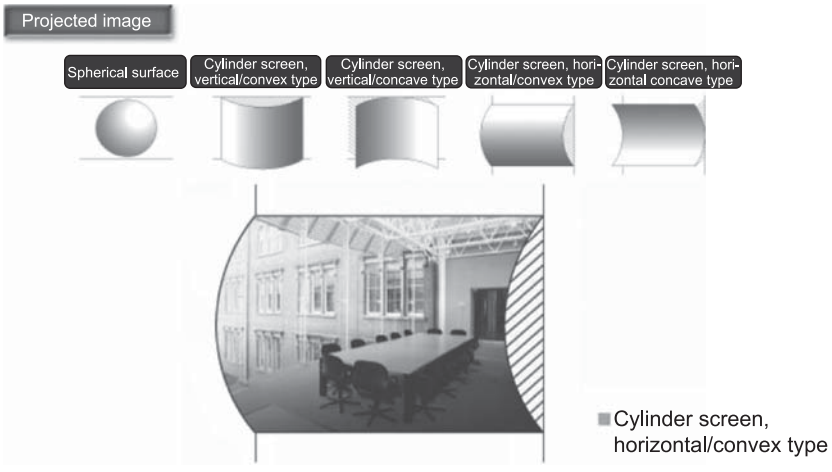
Keywords

projector, geometric distortion correction

1. Introduction

The business projector is an important tool for sharing data among multiple viewers by means of a large screen. It is used in a very wide range of applications, from meetings of a few persons to projections on big screens in large halls. Usage also extends to a wide range, from the mobile-type use of bringing and setting up a projector in a small room for meetings to fixed mounting on ceilings etc. Furthermore, the projected plane is not always a flat and square screen but also includes walls, columns or even spheres. The projection

Fig. 1 Image correction with SQUARE SHOT®.



* This display is an image of a display obtained by the geometric distortion correction function.

Fig. 2 Image correction with geometric distortion correction.

direction is not always a frontal one but is sometimes oblique. To project a distortion-free image under any of these conditions, it is required to correct the projection distortion by performing geometric distortion correction from the projector side.

Since the dawn of business projectors NEC Display Solutions have been providing customers with the "SQUARE SHOT ® " (correction based on four corners) and "geometric distortion correction" functions shown in **Fig. 1** and **Fig. 2** . They are thereby able to deal with the above mentioned usage scenarios. These functions became the solutions that ensure optimal image projection of any image signal that may be input. On this occasion, we have developed a new solution utilizing the computing performance of the PC that meets the recently rising requests to reduce the prices of projectors and to facilitate distortion corrections. The newly developed geometric distortion correction using a PC resource-based image distortion solution allows even those projectors that do not feature this function to perform geometric distortion corrections. This function is available for products from the Image Express Utility Lite (software for projecting the PC screen image with a projector connected through USB or wired/wireless LAN) Version 1.03. The applicable projector models include two series that incorporate a USB display function, namely the NP-M Series of standard models and the NP-P Series of installation models that do not incorporate the geometric correction function.

2. Possible Applications and Solutions

The main applications envisaged for PC resource-based image distortion correction are for mobile use and for use in projecting mainly still images in museums, etc. With the currently typical mobile usage of projectors, the user brings a PC and a projector to a classroom, conference room or meeting corner and installs the projector system there for use. The possibility of completing installation quickly is a very important advantage in this usage scenario. In order to make this possible, projectors intended for mobile use generally use the auto vertical keystone correction function based on the projector inclination information obtained via a sensor as shown in **Fig. 3** . However, vertical keystone correction necessitates that the projector faces exactly to the projected surface (a screen, etc,) and that the projected surface is vertical. But this is not always the case in the actual usage scenario, in which the screens themselves are sometimes distorted (**Fig. 4** , Left). This issue can be resolved with a projector incorporating the geometric distortion correction function as described above, but mobile projectors are incapable of correction unless by using a remote control or by connecting a mouse to the projector and clicking on the four points of the projector image. In the present development, we have succeeded in providing projectors for mobile usage with a simplified means of correction, by which the PC is USB connected to the projector and the user simply has to click on four points on the image displayed on the PC (Fig. 4, Right). **Photo** Shows an example of the actual use of

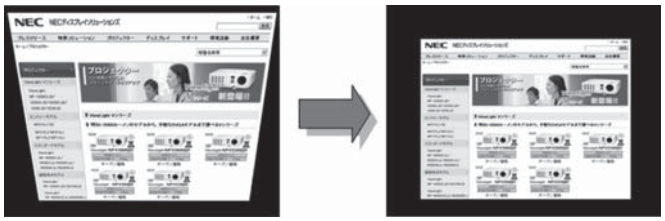
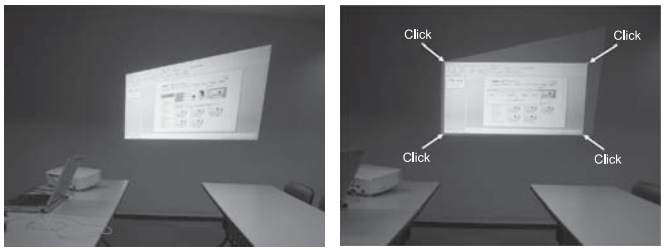


Fig. 3 Image of the action of auto vertical trapezoidal correction.



Before correction After correction

Fig. 4 Image distortion correction with SQUARE SHOT® function (Left: before correction / Right: after correction).

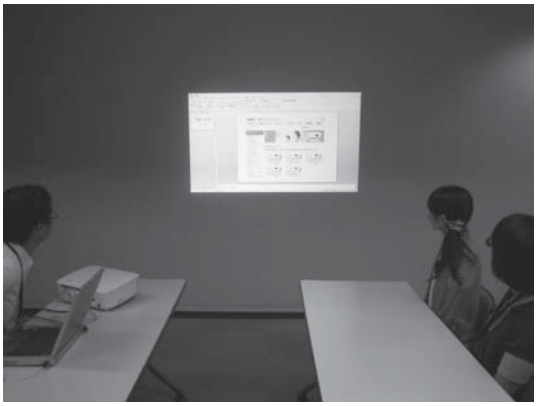


Photo Image of actual use of the SQUARE SHOT® function.

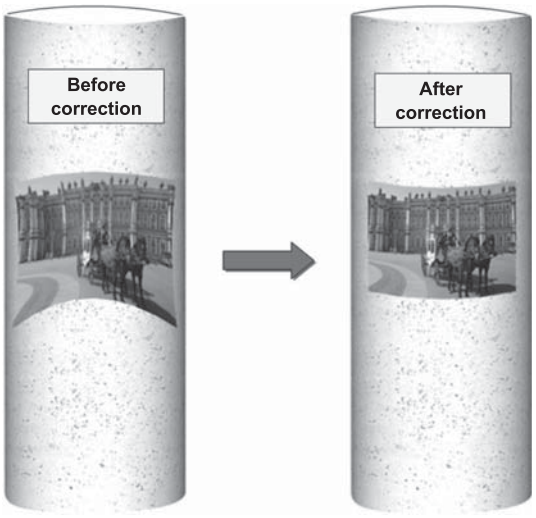


Fig. 5 Example of image projection on a cylinder using geometric distortion correction.

this function. The use of USB connection results of the digital interface can solve various connection issues (auto image frame correction errors, auto phase adjustment errors, auto adjustment time) of the analog RGB connection (D-sub connection).

Projectors are often used to project a slideshow of still images onto a wall or column, and a typical location of such usage would be a museum. For such visual expression, it is very important that the projector offers a wide choice of projection options. The geometric distortion correction function can project distortion-free images even onto a column (**Fig. 5**).

With the traditional installation of projector systems, the distance between the signal source PC and the projector is so long that image degradation is often produced in transmission of the analog RGB signals. On the other hand, as the present development is equipped with a wired LAN capability for transmitting distortion-corrected images, the image quality degradation due to the cable length is eliminated and the installation cost is also reduced due to the use of low-priced LAN cable.

3. Means of Implementation

This section describes how the PC resource-based image distortion correction is implemented. **Fig. 6** shows a processing chart of the PC and the following section describes the processing operations by following the order in which they are executed.

(1) Image capturing

The first processing step is to capture the PC image. The image captured is the one on the primary display.

(2) Geometric distortion correction by software

The image captured in (1) is distorted by the software for performing the geometric distortion correction that is performed by homographic matrix conversion as shown in **Fig. 7** . In this figure, the left diagram shows the captured image and the right diagram shows the image projected from the projector. While the SQUARE SHOT ® function performs correction via a single homographic computation, the geometric distortion correction executes the same number of homographic computations as the number of grid divisions shown in **Fig. 8** . Increasing the number of grids improves the correction accuracy but it also leads to an increase in the burden of correction and editing. Therefore, the user interface is designed to be able to vary the number of grids according to the purpose of use.

(3) Image compression

When transmitting images via a USB or wired/wireless LAN, it is effective to apply irreversible compression to the

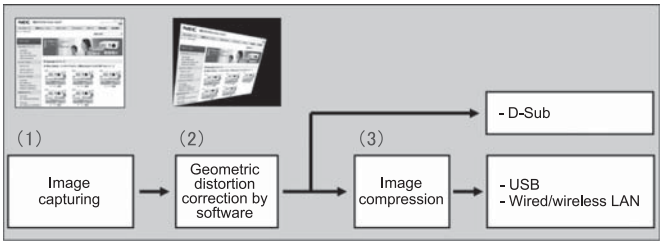
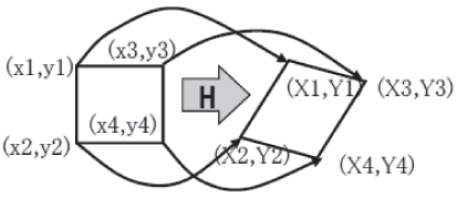


Fig. 6 Image distortion correction processing on PC.



$$s\begin{pmatrix} X \\ Y \\ 1 \end{pmatrix} = \begin{pmatrix} A & B & C \\ D & E & F \\ G & H & 1 \end{pmatrix}\begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

Fig. 7 Image of homographic image conversion, conversion matrix.

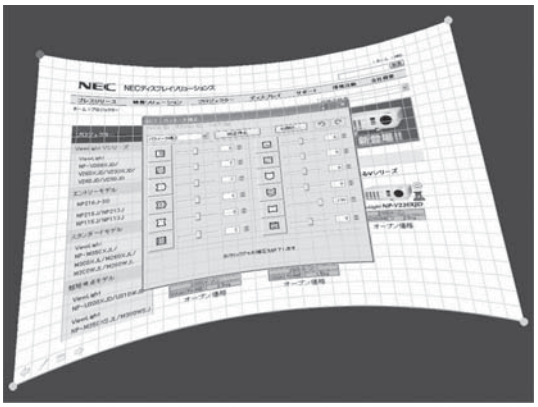


Fig. 8 Geometric distortion correction by grid division.

images and to transmit only those images involving movement in order to reduce the transmission load. With the present development, we have reduced the load on the transmission path by using JPEG compression with a low CPU load and by transmitting only images of the parts involving movement with having incorporated a hardware JPEG decoding engine in the projector for quick decompression of images. On the other hand, the D-Sub output is not compressed because it is an analog RGB output that does not need to be compressed.

4. User Interfaces

Intuitive interfaces are important for geometric distortion corrections. **Fig. 9** shows the user interfaces of the SQUARE SHOT ® and geometric distortion correction functions, while the images of the actual operations are shown in Figs. 4 and 8. **Fig. 10** takes as an example a USB display that transmits images by connecting a PC and the projector via a USB cable. When the projector is connected to a PC, the menu shown in (1) of Fig. 9 is displayed automatically. Now, clicking on the circled icon opens menu (2), clicking the GCT icon circled on the bottom right of the menu opens menu box (3), and clicking on the [Start 4-Corner Correction] button at the bottom of the menu makes the four-point correction ready as shown in Fig. 4.

When the geometric distortion correction function is used, selecting “Parameter correction” from the drop-down box on the left of menu box (3) enables correction using the geometric distortion correction menu (4). This menu is sufficient for

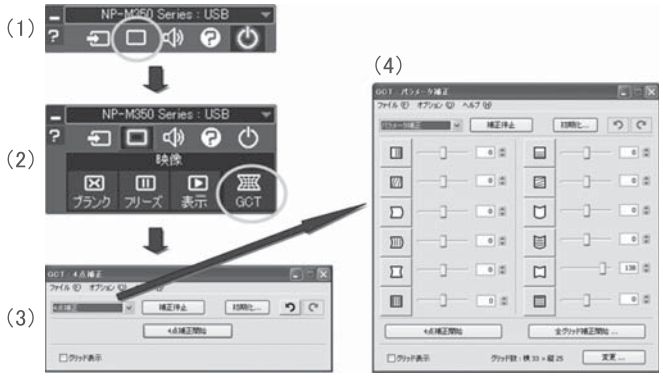


Fig. 9 User interfaces for the SQUARE SHOT® and geometric distortion correction functions.

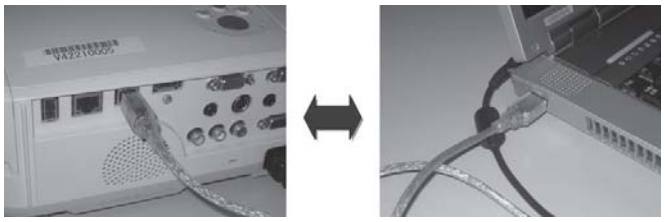


Fig. 10 USB display (USB connection with PC).

Table Image distortion correction performances with PC resource.

Conditions	CPU	Intel® Core™ 2 Duo Clock 2.0GHz
	Display resolution	XGA (1,024 × 768)
	Correction	USB 2.0
	Image used	Moving image of natural picture
Results	Frame rate	10-20 (fps)
	CPU occupancy	Approx. 60% by overall
		Approx. 15% for geometric distortion correction

performing certain degrees of geometric distortion correction, with regard to the shapes of various projected surface. If correction of a higher accuracy is required, clicking on the [Start All-Grid Correction] button on the bottom right of the menu enables correction per point on the grids.

5. Performances

Table outlines the performance of the PC resource-based image distortion correction function incorporated in the new product. Since this function employs a PC, a significant part of

its performance is dependent on the performance of the PC. In addition, the use of image compression technology makes this function's performance greatly dependent on the type of picture contained in the image, the resolution of the display and the amount of motion in the image. Therefore, the performances listed below are the results of evaluations using various moving images. The video display frame rate of the system is between 10 and 20 (fps). This speed is not satisfactory for viewing ordinary video, but it is enough for applications that display mainly still images for presentations in museums etc.

6. Conclusion

As part of our efforts for improving projector functions based on system linkage with a PC, we have recently developed a projector image distortion correction function based on linkage with a PC that enables low cost mobile use of projectors and image correction on irregular surface. This function is marketed as one of the functions incorporated in the PC software called the Image Express Utility Lite. In the future, we aim to further improve usability of this function based on market feedback.

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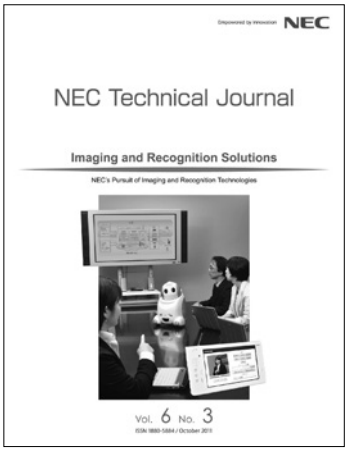

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