Development Guide for Applications That Use AR Cards

2013/02/12

Version 1.3

Confidential

These coded instructions, statements, and computer programs contain proprietary information of Nintendo and/or its licensed developers and are protected by national and international copyright laws. They may not be disclosed to third parties or copied or duplicated in any form, in whole or in part, without the prior written consent of Nintendo.

Table of Contents

Figures

1 Overview

Nintendo has developed NARlib, an AR library for development of CTR applications that use cards as markers for Augmented Reality (AR). NARlib is designed to register several varieties of graphical cards and to be expected to perform real-time recognition of the location and orientation of those cards in real space. Therefore, we do not recommend using NARlib if your goal is to identify and distinguish between a great number of cards in dozens of varieties. In that case we recommend using some other library or developing your own.

This document provides an overview of NARlib, notes the precautions to take when developing your own AR applications, and summarizes information useful when designing your own original AR Cards that differ from the cards packaged with CTR. This document is therefore a useful reference not only for developers who want to use NARlib but for all developers considering development of an AR application.

Note: In this document, the term *AR application* refers to an AR application that uses cards as markers. Although it is possible to develop AR applications that do not use cards, there is no need to refer to this document in such cases.

How to Read This Document

Chapter 2 AR Cards Bundled with the CTR System provides noteworthy points about the six AR Cards bundled with the CTR system. See this chapter if you are considering an application that uses the AR Cards bundled with the CTR system.

Chapter 3 Recognizing AR Cards Using NARlib outlines precautions that apply to all AR applications that use original AR Cards, regardless of whether the applications use NARlib. Read this if you plan to develop an AR application that uses your own original AR Cards.

Chapter 4 Producing AR Cards outlines precautions that apply when using the six AR Cards that come packaged with CTR systems. Read this if you plan to develop an AR application using the AR Cards that come packaged with CTR.

Chapter 5 General Notes describes user support and other issues for developers to be aware of whenever developing an AR application, regardless of whether it uses NARlib. You must read this if you plan to develop an application that uses Augmented Reality.

2 AR Cards Bundled with the CTR System

There are six AR Cards bundled with the CTR system, as shown below.

This chapter explains restrictions regarding the use of these AR Cards.

Figure 2-1 AR Cards Packaged with CTR

| "?" Card | Kirby | Link | Mario | Pikmin | Samus |

2.1 The "?" AR Card

The "?" AR Card is available for application developers to use in their applications. There are no restrictions on the use of the "?" card. Even though this card contains the Nintendo logo, you do not need a separate license from Nintendo to use the Nintendo logo in connection with the "?" AR Card.

 Note: Contact Nintendo if you want to use this card for merchandise, events, and so on.

2.2 The Five AR Cards Depicting Characters

The AR Cards depicting characters are for the exclusive use of applications created by Nintendo. You must not develop applications that use these AR Cards.

3 Recognizing AR Cards Using NARlib

This chapter first describes the NARlib process flow as it recognizes an AR Card. Then it notes precautions for developers to be aware of when designing their own original AR Cards for applications that use NARlib.

Although the following sections assume that AR Cards have white borders, you can use the `mw::nar::Image_cl::SetBorder` function to allow cards to be recognized even if they have black borders.

3.1 AR Card Recognition Sequence

NARlib uses a roughly three-stage process to recognize an AR Card: detection of the AR Card's edges, recognition of the card's design, and recognition of the card's angle of orientation. Each type of recognition is described below.

This information is a valuable reference to help you decrease AR Card misrecognitions when developing applications that use NARlib to recognize your own original AR Cards.

3.1.1 AR Card Detection

When recognizing an AR Card, NARlib first detects the edges of the card. During edge detection the library scans the input image, skipping through it in sections of predetermined width. When it detects a change in brightness of at least a certain magnitude, it examines that area to determine whether it is the edge of the AR Card. For this reason, the outer edges of AR Cards must have a white border of a certain minimum width surrounding an inner black region also of a certain minimum width.

Because the necessary widths of these borders depend on the size of the card and the distance from card to camera when playing the game, it is not possible to state hard numbers that card designs must comply with. However, in the AR Cards that come packaged with CTR systems, the white region and black region have roughly the following widths.

- Vertical: (White region, Black region) = (6 mm, 74 mm)
- Horizontal: (White region, Black region) = (4 mm, 46 mm)

Figure 3-1 Dimensions of the White and Black Regions on AR Cards Packaged with CTR Systems
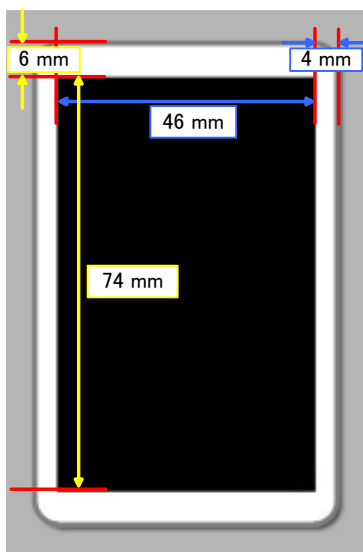

3.1.2 AR Card Design Recognition

Once NARlib has detected an AR Card, it calculates the number of features in the card design.

To calculate the amount of features (the *score*) of the card design, NARlib first divides the interior of the AR card into a 16×16 grid and gets the RGB values of the 15×15 points where the gridlines intersect (the *sampling points*). These RGB values and the values of the sampling points for card designs previously registered in the database are used to calculate the score.

For this step, to create cards that are easier to recognize, design the illustration of the card to differ from other cards more in the placement of characteristic colors than in the other sampling points. *Characteristic colors* refer to the colors with the greatest differences when the averages of the RGB values for all sampling points are compared. You can reduce misrecognition by changing the distribution of characteristic colors for each card.

Figure 3-2 Recognizing the Card Design
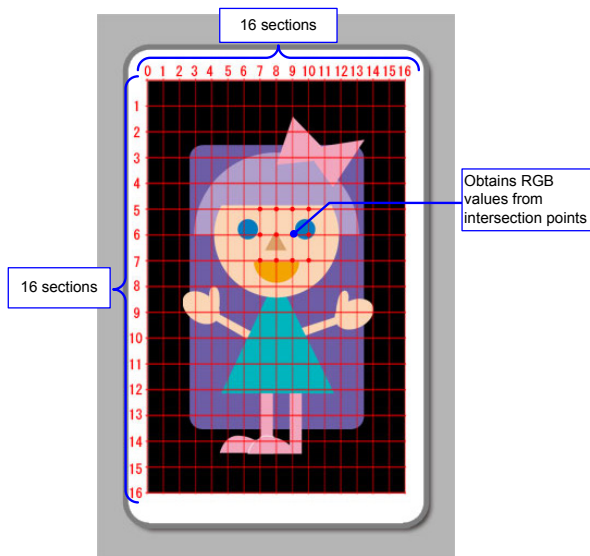
3.1.3 Recognizing the AR Card's Angle of Orientation

In order to render a model on top of the recognized AR Card, NARlib calculates the card's facing direction. These calculations use the fact that the AR Card's black area forms a rectangle in order to yield the card's angles of orientation. This assumption allows NARlib to recognize when cards have been captured at oblique downward angles (as in the input image below) and to generate the matrices needed for model rendering even in these situations.

Figure 3-3 AR Card Captured at an Angle

Released: March 27, 2013
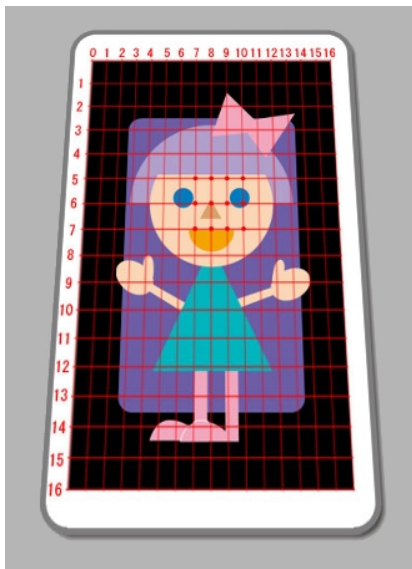
3.2 Easy-to-Detect AR Cards

During edge detection, NARlib scans the image, skipping intervals of a predetermined width. Therefore the outer edges of AR Cards must have white and black border regions of certain widths. As a specific example, the AR Cards packaged with CTR systems have a white border of 4 mm horizontal and 6 mm vertical width and a black border of equal width. The general rule is that the border regions of an AR Card must be at least as wide as one grid square when a 16x16 grid is laid over the interior of the card. To make card recognition easier, we recommend increasing these widths.

Figure 3-4 Card Design Allowing for Easier Detection

For card detection, make the white area at least the size of one grid cell

For card detection, leave at least 1 cell's worth of space in the black area around the illustration
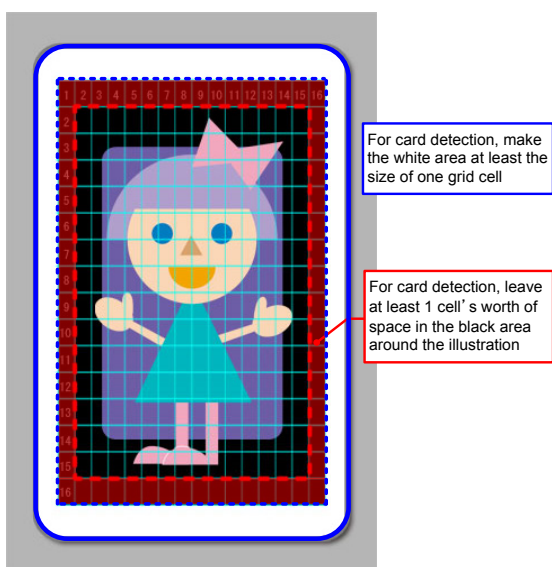
The black area in the AR Card should also form a true rectangle, and the corners should be 90 degrees and not rounded. Otherwise, the library's ability to recognize angles may be degraded.

Figure 3-5 Shape of Black Area to Reduce Recognition Errors
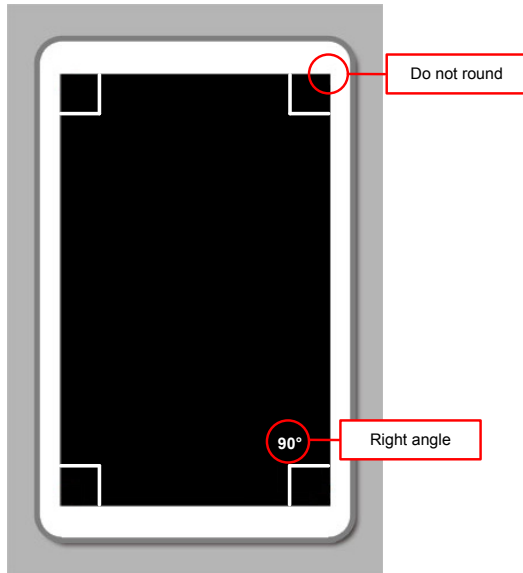
3.3 AR Cards That Can Easily Fail to Be Recognized

3.3.1   Multiple AR Card Designs of Similar Color, Size, and Shape

When NARlib recognizes a card, it takes the RGB values of the sampling points and uses them for reference. For this reason, the more similar two card designs are (in color, size, shape, or other features of the rendered characters), the more likely that NARlib will misrecognize those cards. For example, designs like the following, where only some of the colors are different, are susceptible to recognition errors. Avoid such designs when you design cards.

Figure 3-6 Easily Misrecognized Designs That Differ Only in Color
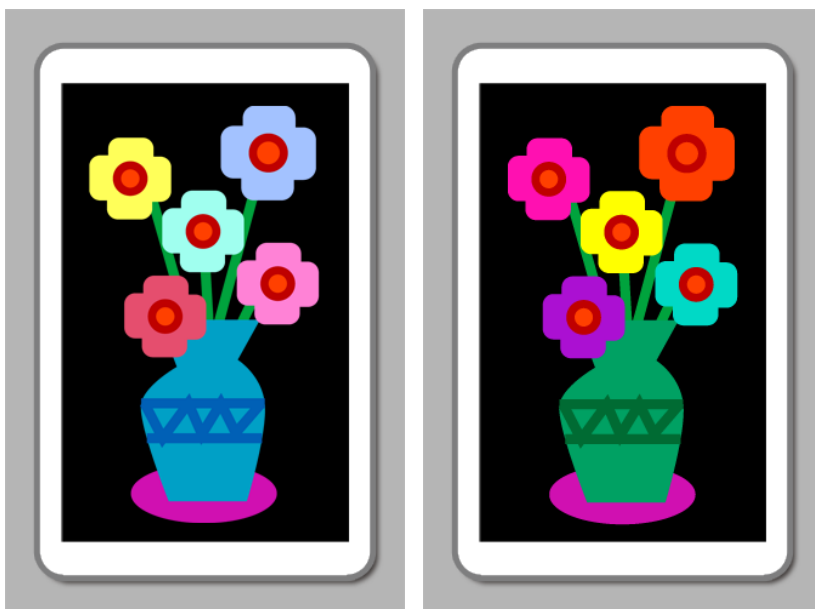
Because the distribution of characteristic colors is similar, the designs shown in Figure 3-6 could easily be misrecognized. The characteristic colors subtract the averages from the actual RGB values, so those differences might be similar even if the actual colors used are different.

Likewise, designs are easily misrecognized when the designs themselves differ but the shapes used in the designs are similar.

Figure 3-7 Easily Misrecognized Similar Designs
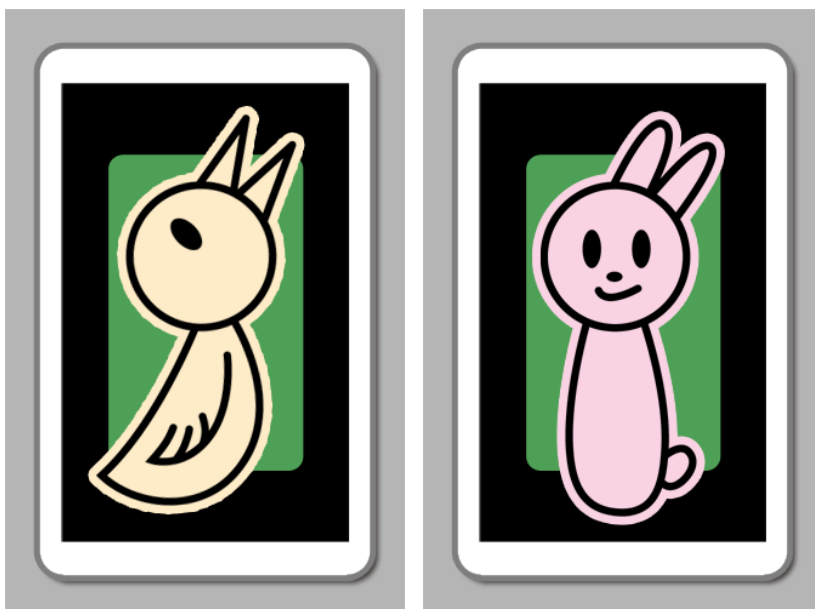
To prevent this sort of misrecognition, rather than just changing the color scheme, it is best to avoid designs that have similar shapes with different color schemes. Designs that have backgrounds with characteristic color placements that differ from those of other cards are also effective.

3.3.2   Placing Sampling Points on Illustration Boundary Lines

The sampling points from which the RGB values are taken can shift slightly vertically or horizontally.

If the illustration's *boundary lines* (the places where the hues change drastically) overlap the sampling points, the likelihood of card recognition failure increases. For similar reasons, card recognition is more likely to fail for highly detailed designs with striking color changes or illustrations that have letters or logos in them. These tendencies become more pronounced when playing at a slight distance from the AR card.

To lessen the likelihood of misrecognition, move the sampling points slightly to a place in the illustration where the changes in hue are not as drastic. If a highly detailed design is unavoidable, the likelihood of misrecognition can be lessened by using contrast rather than hue for differentiation.

Figure 3-8 Easily Misrecognized Finely Detailed Design
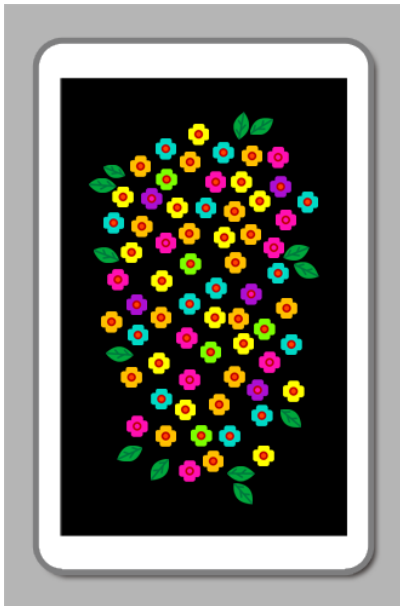
3.3.3   AR Card Designs with Point Symmetry

If an AR Card's design is symmetrical about the point at the center of the card, NARlib cannot determine which side of the card is up versus down and thus cannot render 3D models correctly. Do not design your own original AR Cards to exhibit point symmetry.

Figure 3-9 Designs with Point Symmetry
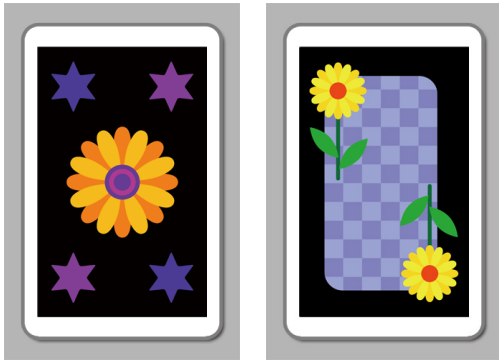
3.3.4   AR Card Designs Composed of Monochromatic Colors

If the overall design of the card is composed of monochromatic colors, it becomes more difficult for the sampling points to be on characteristic colors. Such cards are difficult to recognize with a high degree of accuracy. Similarly, if the illustration is mostly dark, recognition is difficult. Increase the contrast or add effects to create brighter areas.

4 Producing AR Cards

This chapter notes precautions for application developers to be aware of when creating AR Cards. See Chapter 2 AR Cards Bundled with the CTR System if you plan to use the AR Cards packaged with CTR.

4.1 Avoid Designs Easily Misrecognized as the AR Cards Packaged with CTR

All users have a set of the AR Cards that come packaged with CTR systems. If your original AR Card is easily mistaken for one of the AR Cards packaged with CTR system, it might confuse users. When you create your own original AR Cards, choose designs that are not easily confused with the cards that come packaged with CTR. We also recommend taking the following measures to ensure that they are not mistaken for the AR Cards packaged with CTR.

- Do not make cards similar to the common design of the AR Cards bundled with the system (cube silhouette and Nintendo logo).

  If you will be using proprietary AR Cards, although the use of the Nintendo logo is prohibited, avoid using similar designs. Making these parts of the design different will reduces cases of mistaken identity with the AR Cards bundled with the system.

Figure 4-1 Shared Design Elements of the AR Cards Packaged with CTR
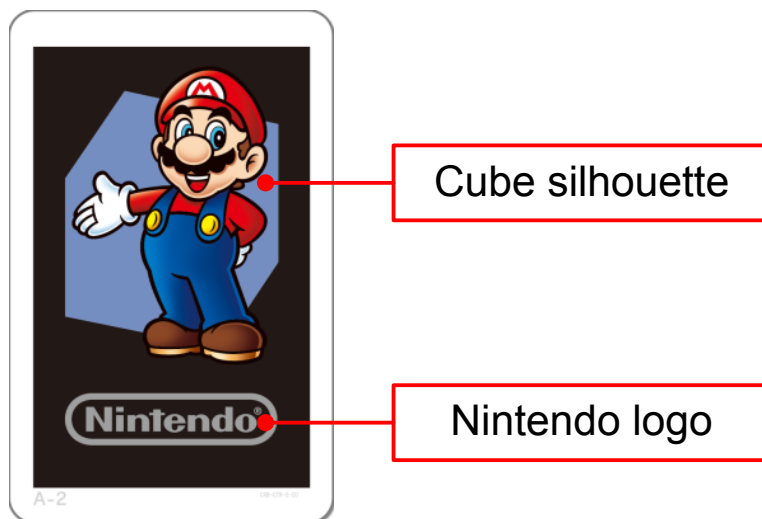

- Do not use a common design if you create more than one original AR Card.

  If you make more than one AR Card, using a common design will increase the chance of recognition errors.

4.2 Print Codes and Serial Numbers

The AR Cards that come packaged with CTR systems have a print code and a serial number used for support printed in the locations shown below. When you create original AR Cards, print a print code and a serial number in the same locations.

Figure 4-2 Printing Locations of Print Code and Serial Number
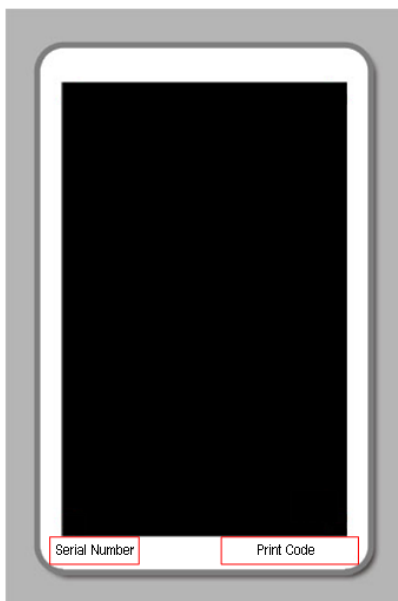
4.2.1 Print Codes

The **CX*-CTR-S-C0** print code is printed on the AR Cards bundled with the CTR system. For the "?" card, the ***** is an **A**. For the five cards depicting characters, the asterisk is **B**, **C**, **D**, **E**, or **F**.

Nintendo Titles

When submitting your AR Card data, leave space for printing the print code.

Non-Nintendo Titles

Please print the print codes on your cards. For more information on print codes, contact Nintendo at support@noa.com.

4.2.2 Serial Numbers

The serial numbers printed on the AR Cards packaged with CTR are used for reference in customer support. For example, "A-1" is printed on the "?" Card, and the rest are printed with "A-2", "A-3", and so on. For forthcoming titles published by Nintendo, we plan to assign the serial numbers "B-1", "B-2", ... , "C-1", "C-2", ..., and so on.

Nintendo Titles

When submitting your AR Card data, leave space for printing the serial number.

Non-Nintendo Titles

Printing a serial number on your cards is not required, but for smooth customer support we recommend setting and printing your own serial numbers.

4.2.3 Notes When Printing

The print codes and serial numbers printed on the AR Cards packaged with CTR have a CMYK color of 0% CMY and 25% K. Avoid printing in a dark color, since that might have adverse effects on card recognition.

5 General Notes

This chapter notes general notes that apply to development of all AR applications.

5.1 Test in Many Environments

The precision of AR Card recognition is greatly affected by the surrounding environment, including the lighting conditions and the various colors of light sources. When developing your application, test it in a wide variety of lighting environments and vary factors such as the light angles, distances, brightnesses, and light source colors.

5.2 Alert the User About Which AR Card to Use

When a user plays your AR application, we recommend that you alert the user, either in the Operations Manual or in-game, of which AR Cards to use when playing the game. This way the user can pick an appropriate AR Card to play with.

For example, we recommend including a message such as "To play this game, use the card that comes packaged with the game," either in the Operations Manual or in-game.

5.3 Be Prepared to Deal with Lost AR Cards

Sometimes users will purchase your game and lose the card. Prepare some method by which such users can obtain cards after the fact. To replace the AR Cards that come packaged with CTR systems, users can download the cards from the Nintendo website.

When you create an original AR Card and make its design available for download from a website, printing by household inkjet printers will cause unintended variation in its color values. When providing a card design on a website, you must always print it on an inkjet printer and confirm that it is possible to reproduce colors equivalent to those on the packaged card.

Revision History

Version	Revision Date	Category	Description
1.3	2013/02/12	Added	• 3.3.4 AR Card Designs Composed of Monochromatic Colors
		Changed	• 3.1.2 AR Card Design Recognition Added information about how to design easily recognizable cards. • 3.3.1 Multiple AR Card Designs of Similar Color, Size, and Shape Added misrecognition causes and workarounds. • 3.3.2 Placing Sampling Points on Illustration Boundary Lines Changed the heading. Added misrecognition causes and workarounds.
1.2	2011/12/20	Changed	• 2.1 The "?" AR Card Modified parts of this section.
1.1	2011/05/18	Added	• 3.3.3 AR Card Designs with Point Symmetry
		Changed	• 2.1 The "?" AR Card Modified parts of this section. • 3 Recognizing AR Cards Using NARlib Noted that cards with black borders can be recognized too. • 3.3 AR Cards That Can Easily Fail to Be Recognized Split this section up into subsections. • 3.3.1 Multiple AR Card Designs of Similar Color, Size, and Shape Revised the section heading.
1.0	2011/03/22	—	• Initial version.

        Released: March 27, 2013

All company and product names in this document are the trademarks or registered trademarks of their respective companies.