Vision SDK

SurroundView Demo Set Up Guide

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1 Introduction

This document describes Surround View Demo (SRV) environment requirements and steps to configure / caliber this demo. SRV is supported as part of demo application in VisionSDK. SRV on TDA2xx platform is support on VisionSDK versioned v02.02.00.00 onwards & SRV on TDA3xx platform is supported on VisionSDK versioned v02.07.00.00 onwards.

1.1 Purpose & Scope

This document details the environment and calibration procedures required for Surround view + Front camera analytics demo.

This document assumes that the audiences of this document are familiar with VisionSDK build procedure, board configurations, required hardware (such as EVM, power supply) etc…

Terms & Abbreviations

SDK	Software development kit.
SRV	Surround View

1.2 Overview

Vision SDK (release v02.02.00.00 onwards) has a demo option for Surround View + Front camera analytics on TDA2xx platform. This demo or use case uses five cameras connected via LVDS to TDA2xx based EVM, stich the output video streams to provide surround view. Output of this demo can be seen on the HDMI display. For more details on LVDS and HDMI connections, please refer user guide.

Four cameras are mounted on four sides of the car. Video feeds from these cameras are used to generate the Surround View output.

Fifth camera is placed on front of the car. Analytics (Edge detection) is performed on the video feed from this camera.

Display layout consists of following:

1. Original feeds from four surround view cameras
2. Generated surround view image
3. Original feed of the front analytics camera
4. Edge detector output
5. Graphics comprising of demo banners, loading of processors

Sample display output is as follows:

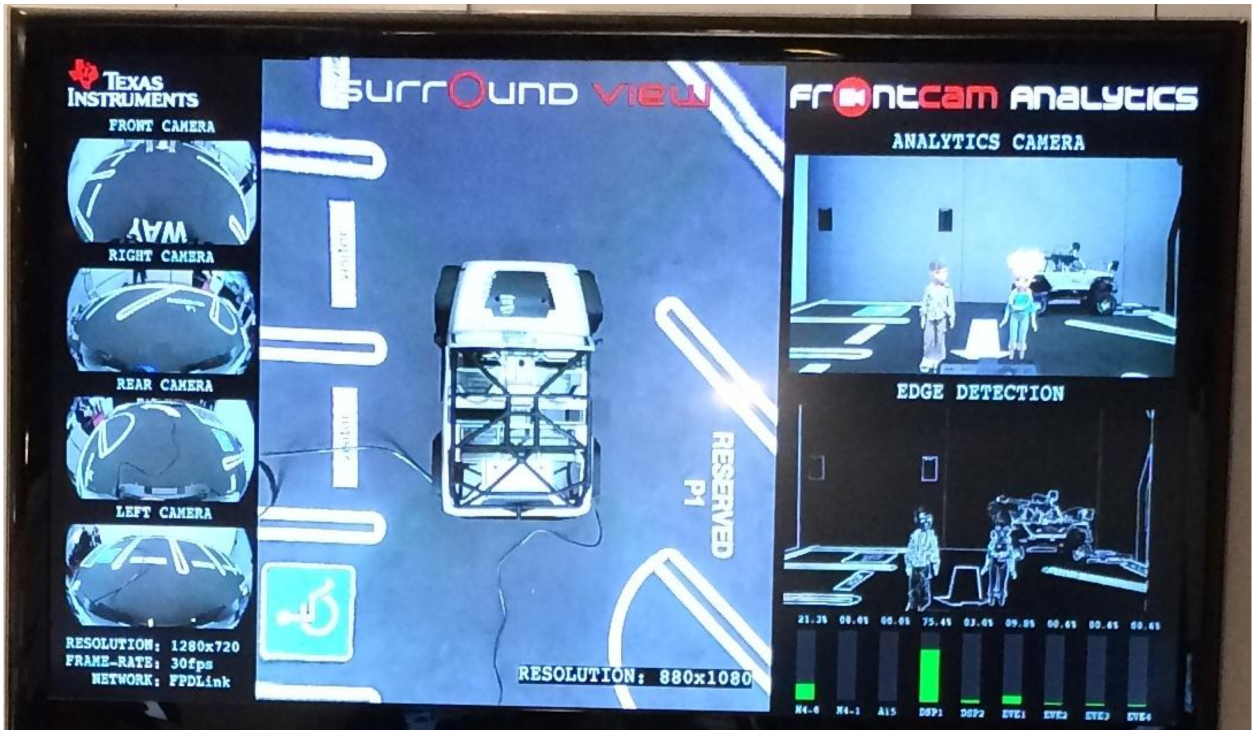
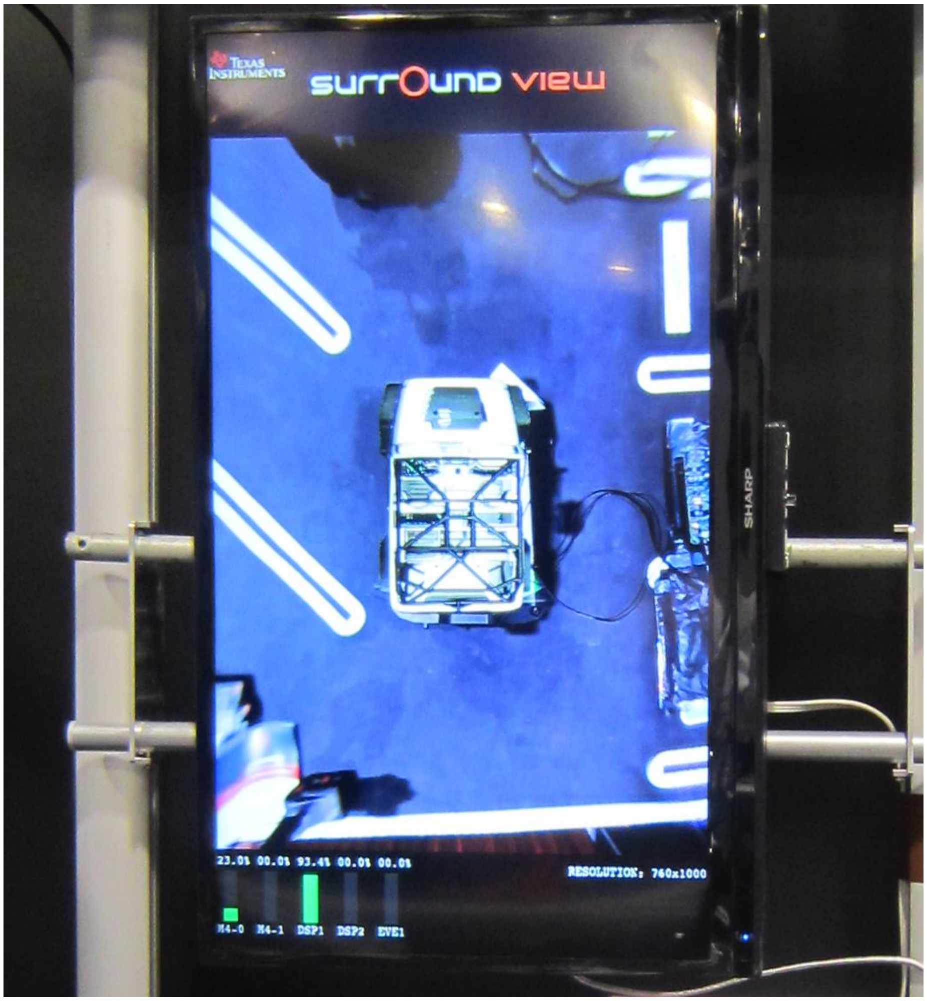


Figure 1: Sample Output Display

1.2.1 TDA3xx Platform

Very similar to TDA2xx platform but the “front camera analytics” is not supported. The hardware required is different for TDA3xx platform, as compared to TDA2xx. Please refer the TDA3xx user guide for details.

Below is a snap shot of the SRV on TDA3xx



2 Demo Set up

This section provides specific details of surround view demo set up.

2.1 Cameras to be used in TDA2xx platform

Four surround view cameras to be used need to have Fish Eye lens (Which have about 180 degrees of view). Fish eye lens to be used is of type DSL219E-670-F2.0 as shown in below diagram. Cameras to be used are of type OV10635.

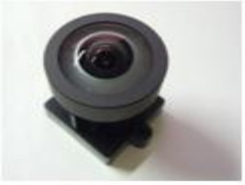


Figure 2 - Fish Eye Lens camera

Front analytics camera can be of a non-fish eye lens camera (OV10635-EAAE-AA0A), as shown below

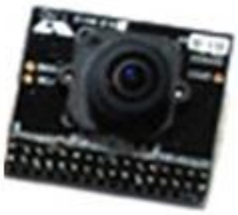


Figure 3 - Simple (Non fish eye) Lens camera

2.2 Cameras to be used in TDA3xx platform

Please refer the TDA3xx user guide for details

2.3 Mounting of cameras

Dimensions of the car (rectangular cube) are as follows - 9 inch width, 21 inch length and about 6 inch height.

Four surround view cameras are mounted at centre of each of the four sides / edges of top of car cube as shown below. Cameras need to be facing ground plane. Hence cameras need to have an inclination of about 45 degrees.

Mapping of surround view cameras to camera numbering mentioned in user guide is as follows:

Front Camera – Camera 1

Right Camera - Camera 2

Rear Camera - Camera 3

Left Camera - Camera 4

On TDA2xx platform, front analytics camera is placed on the front side in such a way that its view is not blocked by the car or other camera.

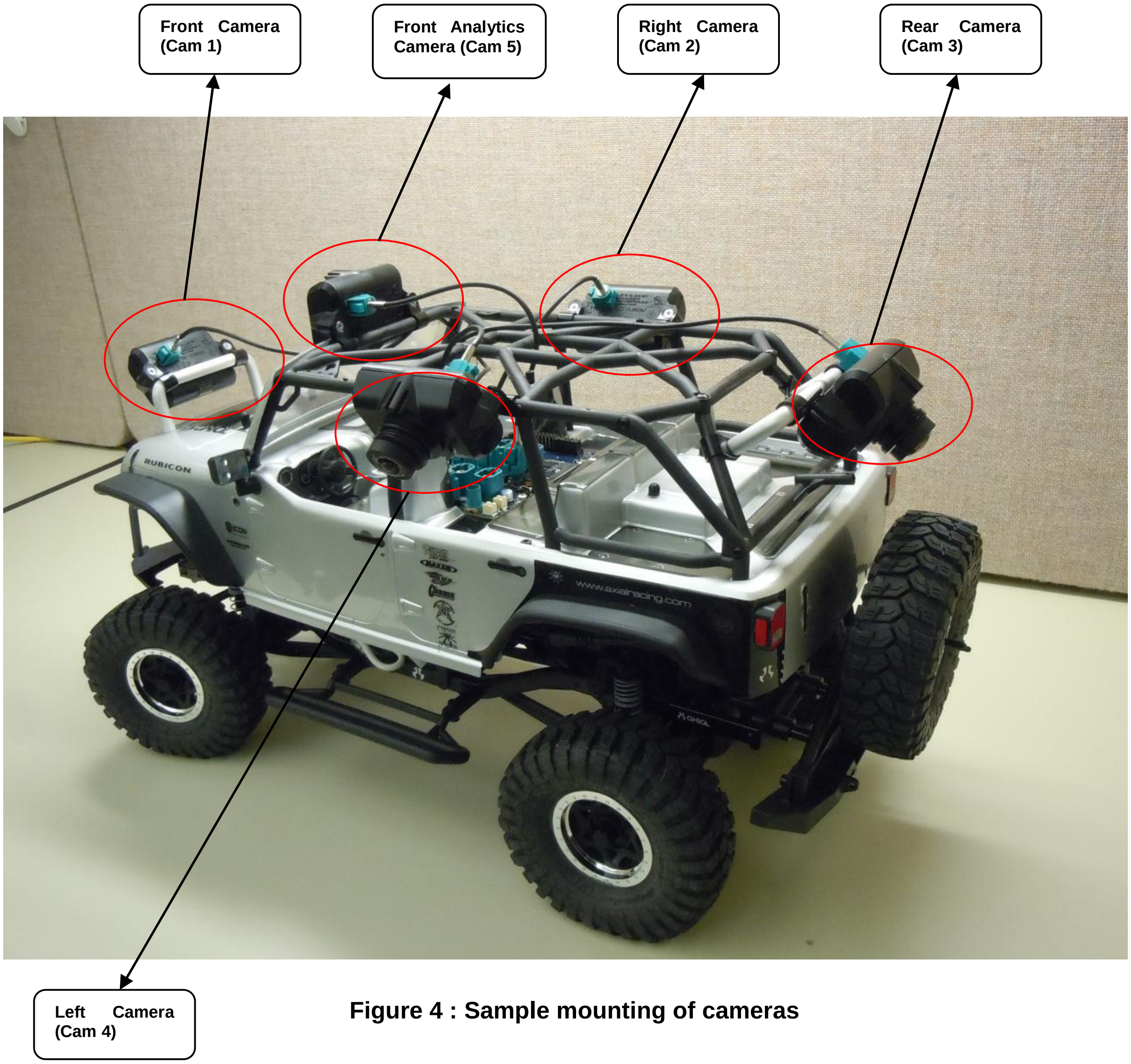
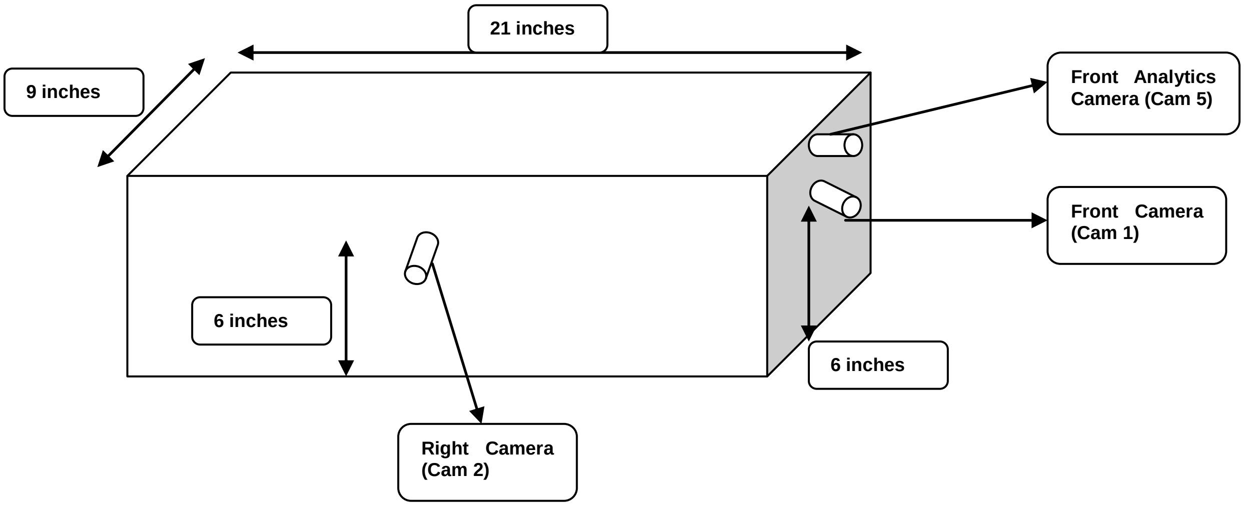


Figure 4 : Sample mounting of cameras

Note that the cameras need to be mounted firmly, so that during usage, camera positions do not get altered.

For general development purposes, a car is not needed. Cameras can be mounted on any rectangular cubic setup / cubic arrangement as follows. However height, width, length and angle of mounting need to be adhered to.



Left and rear cameras are mounted on other two sides of the cube (Hidden in above figure).

2.4 Sample Non-calibrated output

Surround view output generation use certain geometric mapping tables and the output quality is sensitive to these table values. These table values need to be calibrated based on the actual given set up. Vision SDK release has certain default tables, which will give an output which is not best aligned. Below is a sample of non-calibrate output. Note that, along the diagonals of the surround view output, images from two views do not have smooth transition.

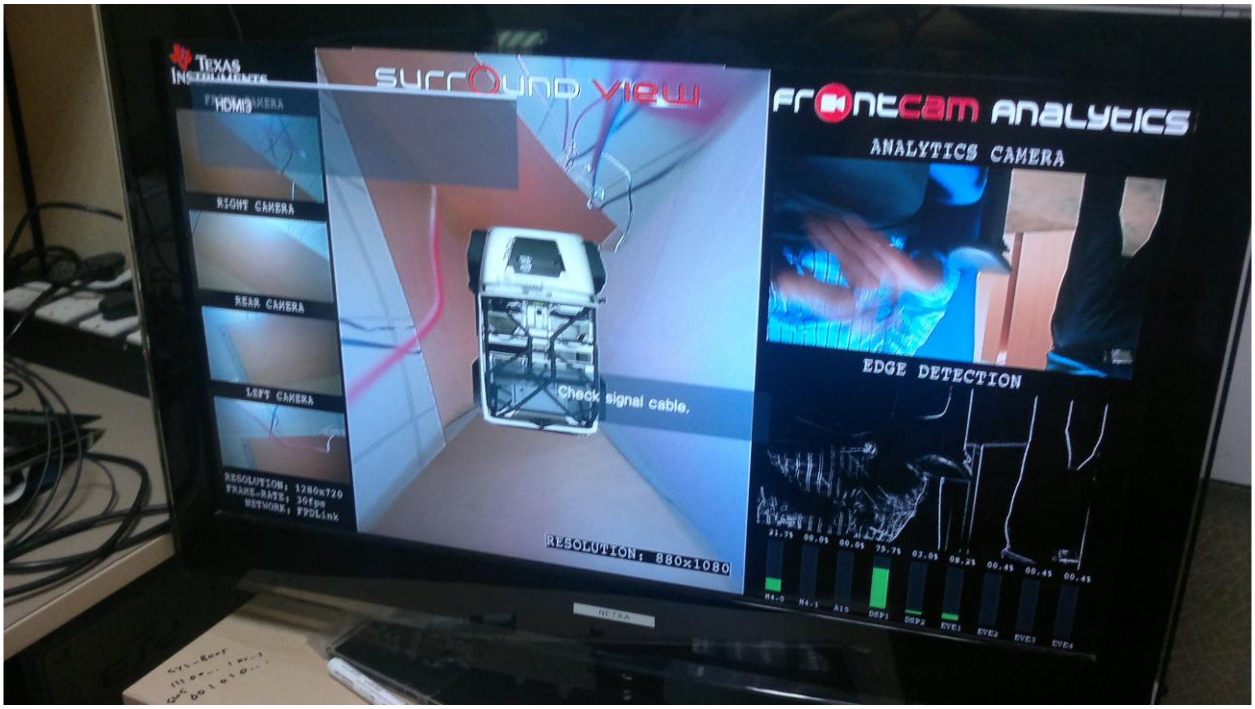


Figure 5 - Sample output without calibration

2.5 A Brand-new Calibration

To obtain best quality surround view output, proper geometric calibration tables for the given demo set up need to be used.

When the demo is set-up for the very first time, calibration images may need to be extracted from the EVM to obtain correct geometric calibration table. This involves following two steps:

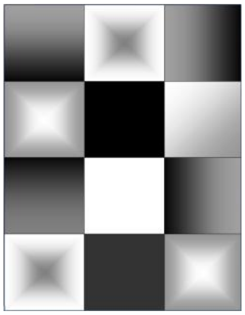
Step1: Obtain surround view images for the given set up.

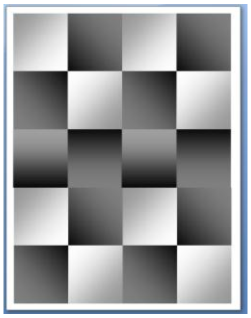
Step2: Share images with TI FAE / Contact to receive calibration tables.

Step3: Using new calibration tables

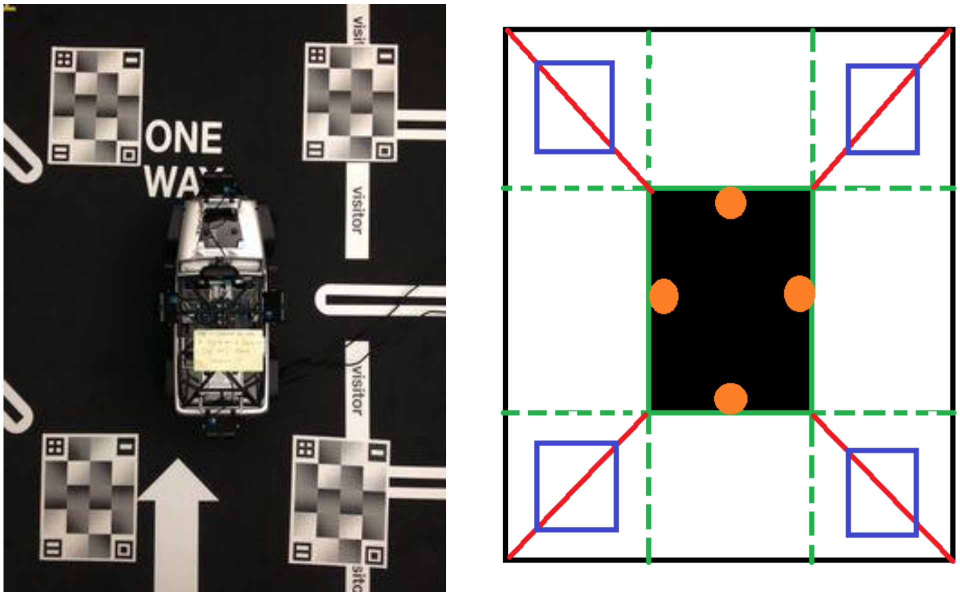
2.5.1 Obtaining Surround View Images for the given set up

1. Four print outs of the below checkered pattern needs to be taken in an A4 sheet size paper. You can use either one of the patterns shown below.





2. These checkered print outs need to be placed around the car as shown below.



(a) (b)

Figure 6 - Positioning of calibration charts. (a) An example of the reference picture which shows how charts are placed around the jeep. (b) Further illustration of how charts should be placed. The black box (i.e., the car box) in the middle of the image is where the graphics of the jeep will appear. The car box should encompass surround view cameras inside (i.e., the orange circles). From the car box, green dotted lines are drawn to show the overlapping regions between adjacent cameras. The red lines are the diagonal lines of each overlapping region. Each calibration chart (blue squares) should be placed inside the overlapping region, roughly symmetrical against the red diagonal lines. Please follow steps 3-5 listed below for additional calibration requirement.

3. Important to keep all these checkered patterns on a non-reflective surface, with uniform lighting. Note that the demo should be set-up on non-reflective surface. Glares from the floor will cause problems for both geometric alignment and photometric alignment.
4. Make sure no wires or cables go through the charts, and people are not standing too close to the charts.
5. Another thing to note is that each camera must clearly capture all the corners of the two checkered patterns coming in its view as below.

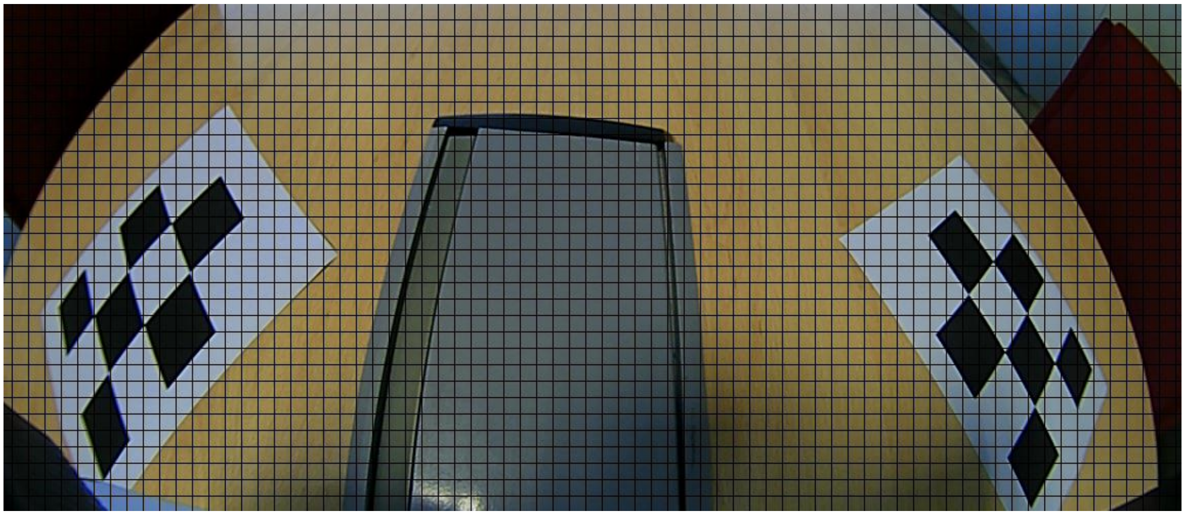


Figure 7 - Each view capturing two charts fully

6. These images need to be dumped out from DDR memory, while running the demo, using following steps:
    a. Build code of IPU1_0 in Debug mode (Control via Rules.make)
    b. Run the demo in the usual manner
    c. Insert a break point on IPU1_0 CPU at return statement inside function SyncLink_makeCompositeBuffer () present in file \VISION_SDK_02_02_xx_xx\vision_sdk\src\links_common\sync\syncLink_tsk.c
    d. Upon hitting break point, drag pSysCompBuf to watch window of CCS
    e. Check the value of pSysCompBuf ->numFrames. If it's not 4, then just give free run until it hits this break point again with value of pSysCompBuf ->numFrames being 4.
    f. Once value of pSysCompBuf ->numFrames is 4, then record four pointers pSysCompBuf ->bufAddr[0][0], pSysCompBuf ->bufAddr[0][1], pSysCompBuf ->bufAddr[0][2] and pSysCompBuf ->bufAddr[0][3]
    g. Above four pointers give addresses in DDR where the images from four surround view cameras are stored in YUV420 Semi-planar format.
    h. From these addresses take a memory dump in RAW format using CCS save data option. Number of bytes to be dumped out = (1280*720*1.5) = 1382400 bytes. Select 8-bit as dumping mode and file dump needs to be saved in *.bin format.
    i. Just open above dumps in any YUV viewer so as to make sure that the dumped out content is the image from the four cameras.
7. Either before or after dumping the frames, capture a reference bird-eye view image with a camera for your current setting. When taking the reference, not only camera positions should not change, charts positions and jeep position should all remain the same. You can take the reference image with a camera, try

to give the camera a perfect bird-eye view of the jeep such that all the charts have equal sizes in the reference. One example is shown in Fig. 6.

8. In case of TIDA00455/OV490 based surround view use-case, if video contains green artifacts throughout the image, try toggling the pixel polarity.

   In case of BIOS setup, run-time menu provides an option to toggle the polarity while running the use-case.

   In case of Linux setup, use the following command - "omapconf write 0x4A002534 0x0". To revert use "omapconf write 0x4A002534 0x5". 0x5 is the recommended setting – it might vary based on different OV490 firmwares/board versions/etc. This command can be run before running vision_sdk_linux_demo.out or while the use-case is running from another terminal by connecting via telnet.

2.5.2 Contact TI FAE / Support

Share the above four frames as well as the reference bird-eye image with TI FAE / Contact to obtain geometric tables for the given demo set up.

More details on how to obtain initial geometric tables using calibration tool is given in Section 3.

2.5.3 Using new calibration tables

1. In the file \vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignExt_tda2xx.c replace the array permatin[] with the newly provided geometric tables and in file \vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignLUT_tda2xx.c replace the array GAlignLut []. Rebuild the Vision SDK code with above change.
2. On TDA3xx platform, update following files\vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignExt_tda3xx.c replace the array permatin[] with the newly provided geometric tables and in file \vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignLUT_tda3xx.c
3. Run the demo and select option "2: Erase entire calibration tbl from flash"

- Above will erase old tables, if any in QSPI flash.

4. And then in the next run, pick option "Run with GA LUT from flash (If not available, use default table)"

- Above will use the tables included in the code, since there are no tables in flash.

After using the correct geometric tables, surround view output should not have any geometric misalignments along the diagonals (common view of two cameras) as shown below. Note that the checkered patterns do not have any distortion.

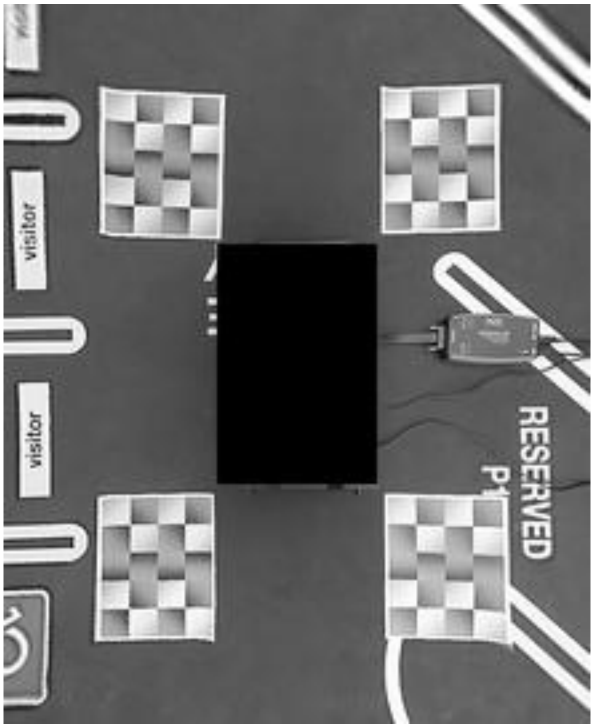


Figure 8 - Output with perfect geometric alignments.

2.6 Re-Calibrating Existing Demo Set-up

After the current set-up has been calibrated, try to keep all the cameras positions as fixed as possible. If for any reason, one or more camera positions are changed, and the output surround view becomes misaligned, then it means the current surround view demo requires a re-calibration. This normally can be achieved by the on-line calibration software.

To do that, first place the calibration charts on the floor around the demo set-up following instructions given in Sec 2.4.1. Next, power-cycle the EVM. The calibration will complete in a few seconds, and the fully aligned output will shown on the screen. The correct new geometric alignment tables have been obtained and saved automatically.

If on-line calibration fails, the output surround view will look misaligned. In this case, first try to slightly adjust the position of the cameras by hand to achieve calibration. If it does not work, then following "Step 6" in Sec. 2.4.1 to extract the calibration images from EVM, and send calibration images to FAE to get the new geometric alignment tables.

3 Calibration Tool

3.1 Purpose for using this tool

This interactive tool produces the initial perspective matrix for Geometric Alignment algorithm using four input frames, one reference bird-eye image, and user selected corners.

3.2 Prerequisites

Verify the MATLAB Compiler Runtime (MCR) is installed and ensure you have installed version 8.2 (R2013b). MCR 8.3 can be obtained for free from the Mathworks website.

If the MCR is not installed, do the following:

(1) Run “MyAppInstaller_mcr.exe” to install or

(2) Run “MyAppInstaller_web.exe” to download it from the web

3.3 Input files required by the tool

This tool requires four surround view calibration frames and a bird-eye reference image.

3.3.1 Obtain four surround view calibration frames

Please follow instructions given in Sec. 2.4.1 step 1 – 6 to obtain the surround view calibration frames.

Mapping of surround view cameras to camera numbering mentioned in user guide is as follows:

Front Camera – Camera 1

Right Camera - Camera 2

Rear Camera - Camera 3

Left Camera - Camera 4

3.3.2 Obtain bird-eye reference image

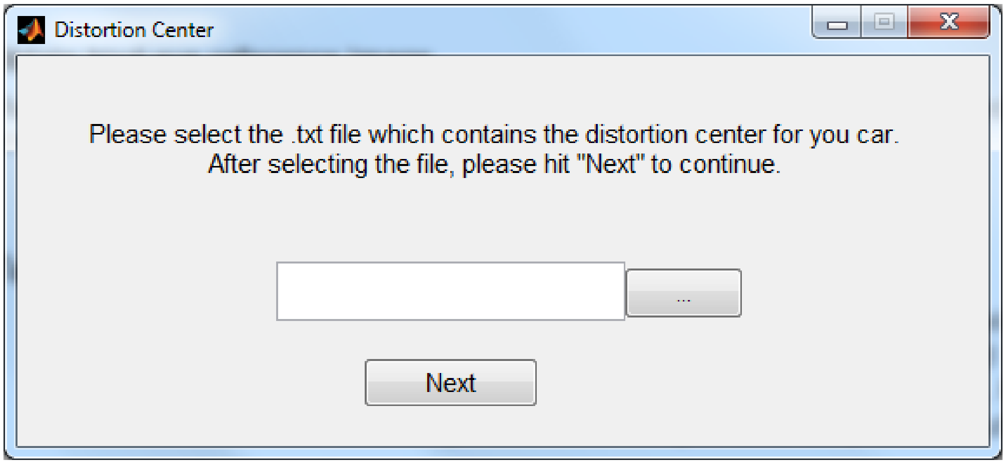
Please follow instructions given in Sec. 2.4.1 step 7 to obtain the bird-eye reference image. One example is shown in Fig. 6.

3.4 Tool Instruction

1. By running “calibration_tool.exe” in folder ./calibration_tool/, first you will see the windows shown in Figure 9. It will ask you to select the .txt file which contains the distortion center. For Jeep No. 1 – 8, the files have already been generated. For new assembled car, please refer to Sec. 4 to generate new distortion center file.
2. Enter other parameters needed for calibration, as shown in Figure 10. Please follow the instructions for entering the parameters. If you have DSP code and you changed any of the default values for “Focal Length”, “Output Height & Width”, “Car Box Size Horizontal & Vertical” or “Camera Image Height, Width or Pitch”, change the value here, too. Otherwise, leave default values.

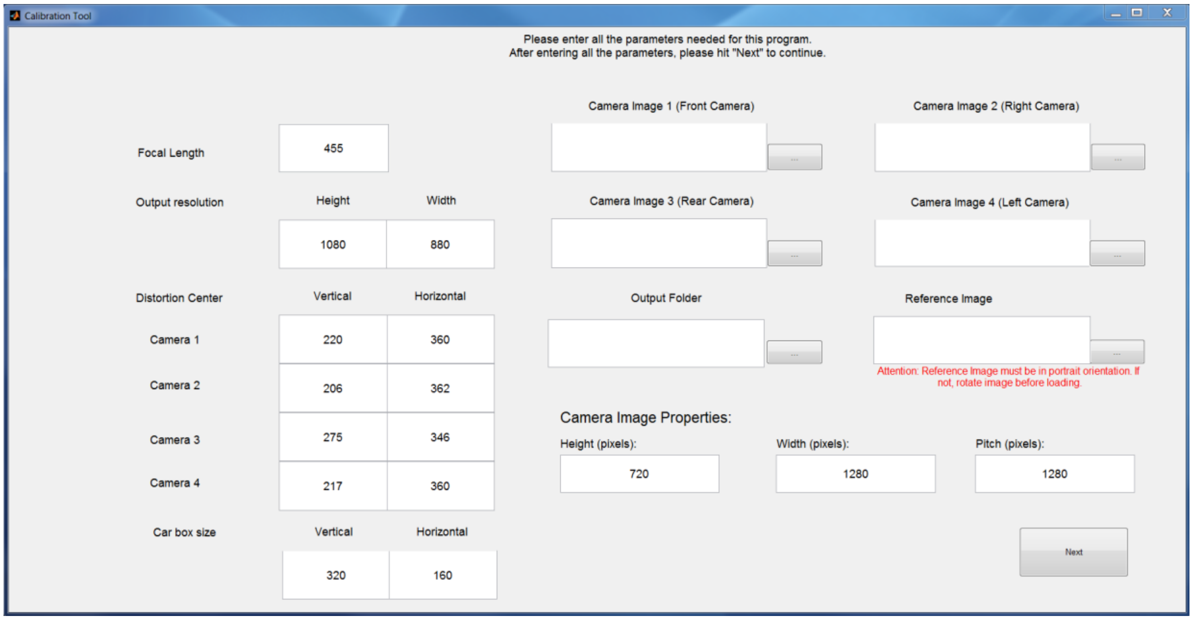
In this interface, select the output directory to be the same folder as where the input frames are located, and load input frames (yuv) and reference image (jpg).

Reference image must be in portrait orientation. Rotate the image before loading if it is not.



Please select the .txt file which contains the distortion center for you car.
After selecting the file, please hit "Next" to continue.

Figure 9 – Calibration Tool start window.



Please enter all the parameters needed for this program.
After entering all the parameters, please hit "Next" to continue.

Focal Length: 455

Output resolution	Height	Width
	1080	880

Distortion Center	Vertical	Horizontal
Camera 1	220	360
Camera 2	206	362
Camera 3	275	346
Camera 4	217	360

Car box size	Vertical	Horizontal
	320	160

Camera Image 1 (Front Camera)

Camera Image 2 (Right Camera)

Camera Image 3 (Rear Camera)

Camera Image 4 (Left Camera)

Output Folder

Reference Image

Attention: Reference Image must be in portrait orientation. If not, rotate image before loading.

Camera Image Properties:

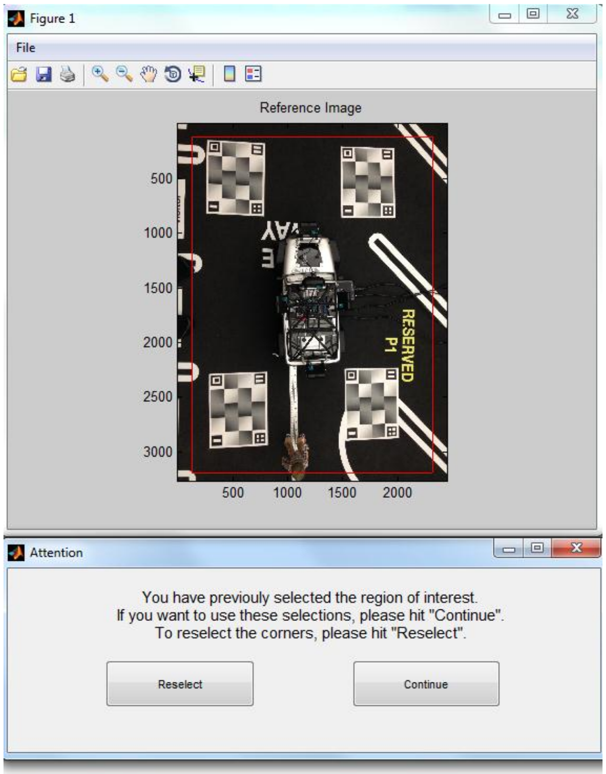
Height (pixels):	Width (pixels):	Pitch (pixels):
720	1280	1280

Figure 10 – Enter parameters.

3. Crop the reference image

The purpose of cropping is to create a reference that more tightly encloses the calibration charts (i.e., reducing field of view), as well as having the jeep centered in the frame. This can ensure the best quality for surround view output.

If you have cropped the reference image before, the coordinates will be saved in your chosen output directory. The program will show you the previous selected region of interest and ask whether if you would like to use that data, as shown in Figure 11. You can hit “Continue” to use the previous selection or hit “Reselect” to reselect the region of interest.



You have previouly selected the region of interest.
If you want to use these selections, please hit "Continue".
To reselect the corners, please hit "Reselect".

Figure 11 – Previous selected region of interest.

If you have not selected the region before or you choose to reselect the region of interest, you will be asked to select the upper-left corner and the lower-right corner of the desired cropping region using you cursor. This interface is shown in Figure 12.

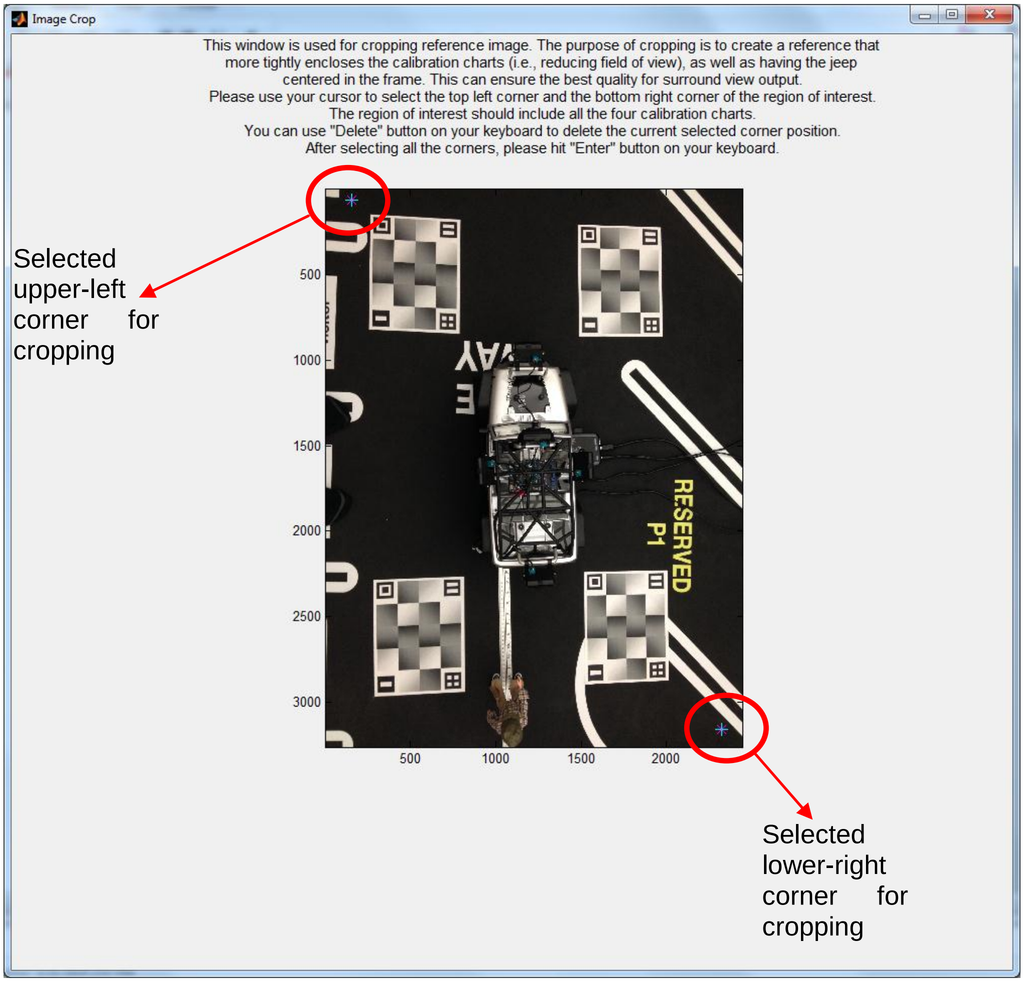


Image Crop

This window is used for cropping reference image. The purpose of cropping is to create a reference that more tightly encloses the calibration charts (i.e., reducing field of view), as well as having the jeep centered in the frame. This can ensure the best quality for surround view output.
Please use your cursor to select the top left corner and the bottom right corner of the region of interest.
The region of interest should include all the four calibration charts.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

Selected upper-left corner for cropping

Selected lower-right corner for cropping

Figure 12 – Crop reference image.

After successfully select the two points, you will get a message at the bottom of the window as shown in Figure 13. If you are not satisfied with the selection, you can follow the instruction and hit “Redo” to reselect the points.

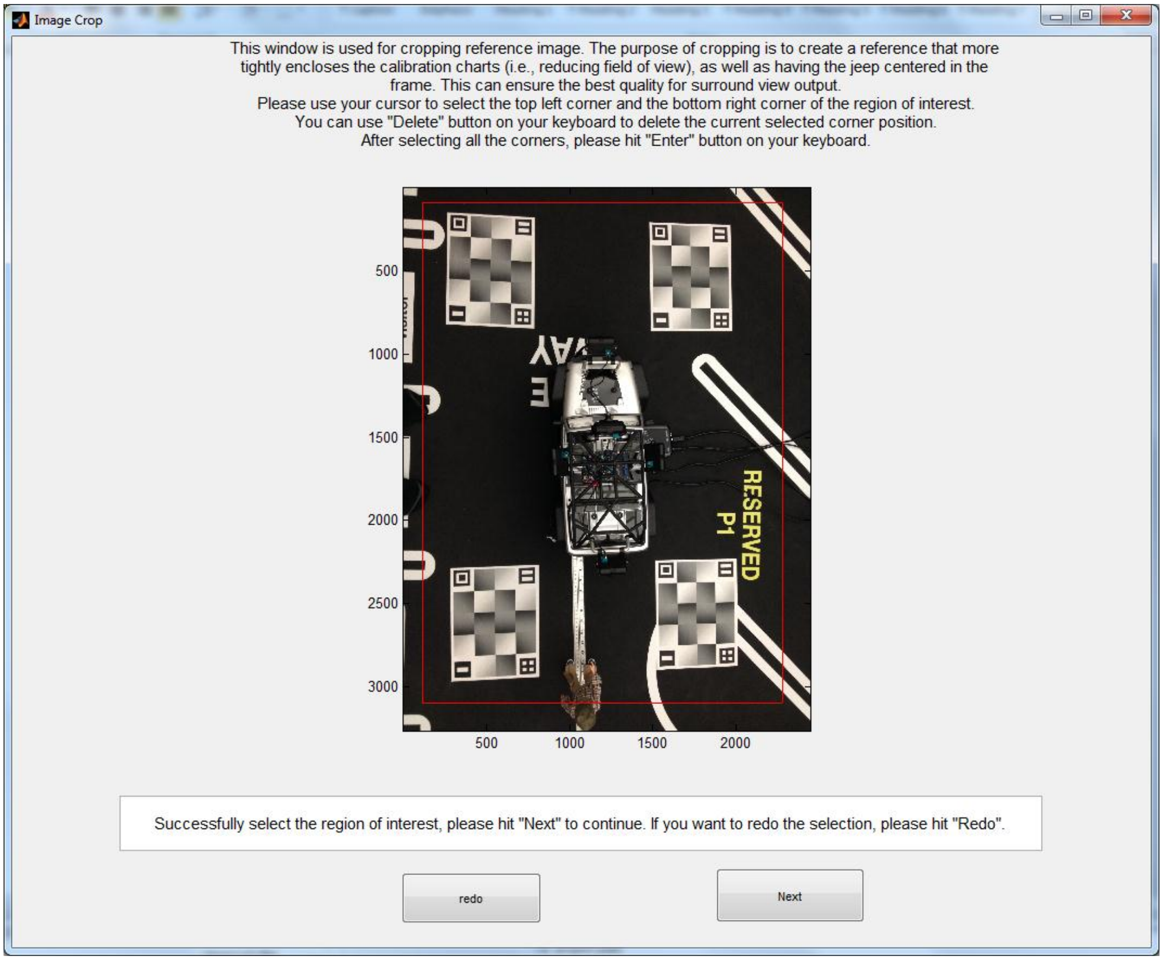


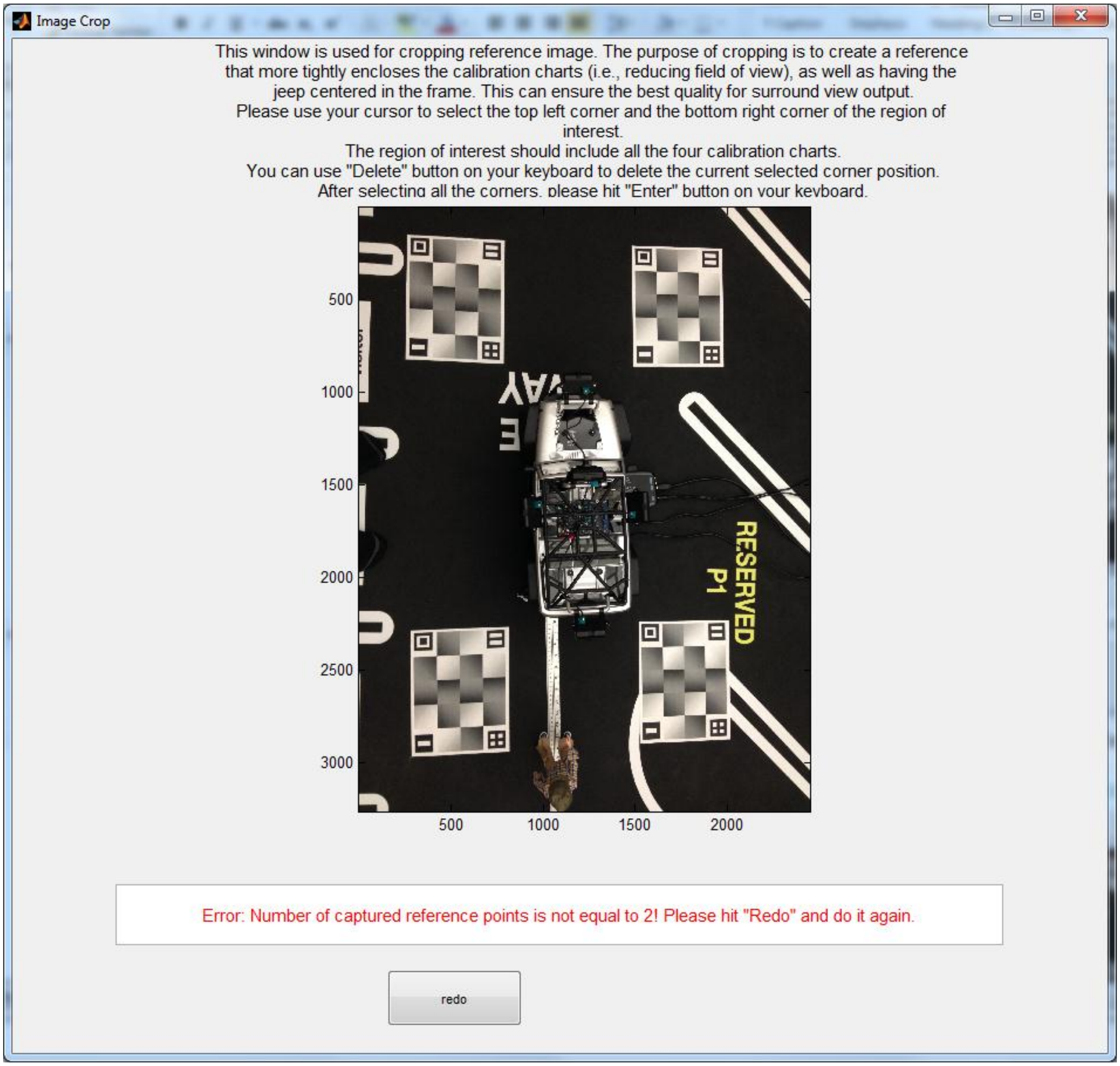
Image Crop

This window is used for cropping reference image. The purpose of cropping is to create a reference that more tightly encloses the calibration charts (i.e., reducing field of view), as well as having the jeep centered in the frame. This can ensure the best quality for surround view output.
Please use your cursor to select the top left corner and the bottom right corner of the region of interest.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

Successfully select the region of interest, please hit "Next" to continue. If you want to redo the selection, please hit "Redo".

Figure 13 – Successfully select the points to crop reference image. The region with red borders will be the cropped reference image.

If you did not successfully select the points, you will get a message at the bottom of the window as shown in Figure 14. Please follow the instructions to reselect the points.

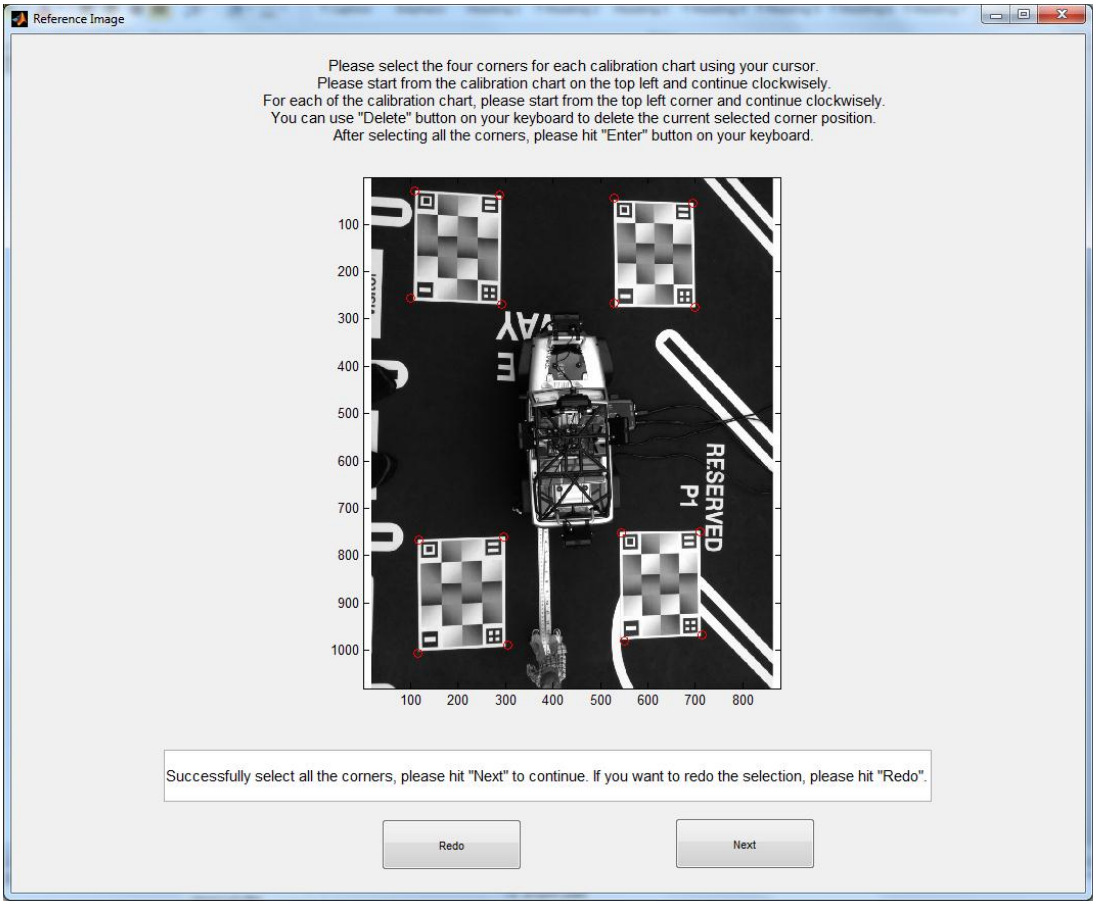


This window is used for cropping reference image. The purpose of cropping is to create a reference that more tightly encloses the calibration charts (i.e., reducing field of view), as well as having the jeep centered in the frame. This can ensure the best quality for surround view output.
Please use your cursor to select the top left corner and the bottom right corner of the region of interest.
The region of interest should include all the four calibration charts.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

Error: Number of captured reference points is not equal to 2! Please hit "Redo" and do it again.

Figure 14 – Cropping reference image failed, wrong number of points are selected.

4. Select the corner positions in reference image as shown in Figure 15. Please follow the instructions on the GUI, you will get a message indicating whether you have succeeded to select the points as shown before.



Please select the four corners for each calibration chart using your cursor.
Please start from the calibration chart on the top left and continue clockwisely.
For each of the calibration chart, please start from the top left corner and continue clockwisely.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

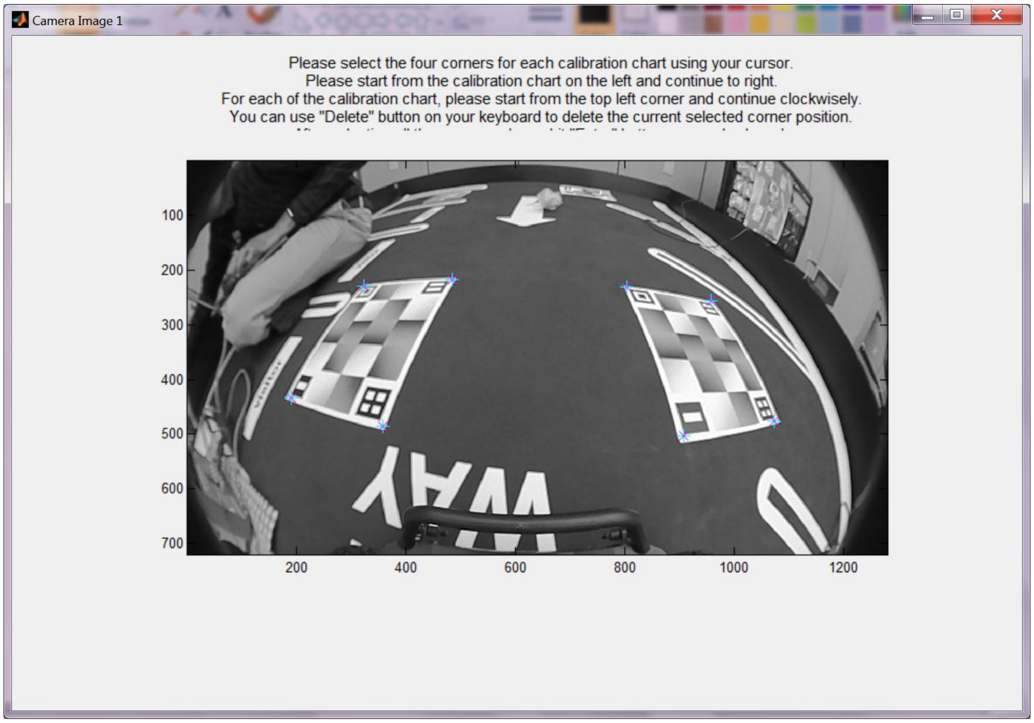
Successfully select all the corners, please hit "Next" to continue. If you want to redo the selection, please hit "Redo".

Figure 15 – Select corner positions in reference image.

5. Select corners in each of the four input camera frames.

   There are only two charts and a total of 8 corners to select for each input camera frame. Start with the left chart, click on the upper left corner first then go clock-wise to click on the rest of the three corners. An example is shown in Fig. 16. After finishing the left chart, following the same procedure to select the four corners in the right chart.

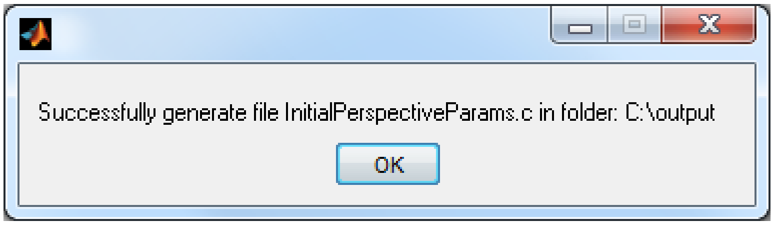
   Repeat this process for all four input frames.



Please select the four corners for each calibration chart using your cursor.
Please start from the calibration chart on the left and continue to right.
For each of the calibration chart, please start from the top left corner and continue clockwisely.
You can use "Delete" button on your keyboard to delete the current selected corner position.

Figure 16 – Select 8 corners in the input frame

6. Finally, you will get a message saying that you have successfully gone through the calibration process. You will find two output files (.c and .csv) in your selected output folder. The .csv file is needed for the SurroundView.exe demo PC code. XXX



Successfully generate file InitialPerspectiveParams.c in folder: C:\output

Figure 17 – Calibration process finished message.

4 Fish-eye distortion center tool

4.1 Purpose for using this tool

This interactive tool estimates the fish-eye lens distortion centers for the four input cameras. The results will be saved to an txt file, and subsequently used by the Calibration Tool to generate initial perspective matrix.

Fish-eye distortion centers only need to be obtained once for a new set of cameras/lens.

4.2 Prerequisites

Verify the MATLAB Compiler Runtime (MCR) version 8.3 is installed. MCR 8.3 can be obtained for free from the Mathworks website.

4.3 Input files required by the tool

This tool requires four surround view calibration frames. Please follow instructions given in Sec. 2.4.1 step 1 – 6 to obtain the surround view calibration frames.

Mapping of surround view cameras to camera numbering mentioned in user guide is as follows:

Front Camera – Camera 1

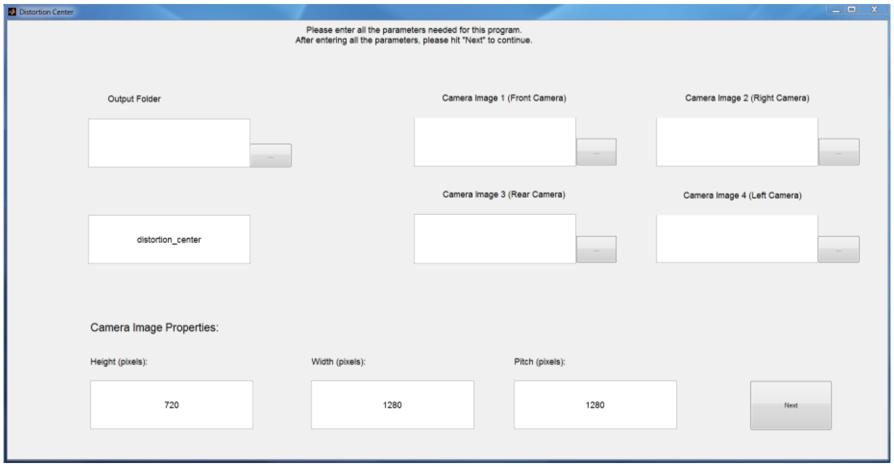
Right Camera - Camera 2

Rear Camera - Camera 3

Left Camera - Camera 4

4.4 Tool Instruction

1. By running "fisheye_tool.exe" in folder ./fisheye_tool/, first you will see the windows shown in Figure 18. It will ask you to select input file, output folder and output filename. Choose output folder to be the same as where the camera images are located. Also, specify the height, width and pitch of the input camera images, if they differ from the default values.



Distortion Center
Output Folder
Camera Image 1 (Front Camera)
Camera Image 2 (Right Camera)
Camera Image 3 (Rear Camera)
Camera Image 4 (Left Camera)
Camera Image Properties:
...
Next

Please enter all the parameters needed for this program.
After entering all the parameters, please hit "Next" to continue.

distortion_center

Height (pixels): 720

Width (pixels): 1280

Pitch (pixels): 1280

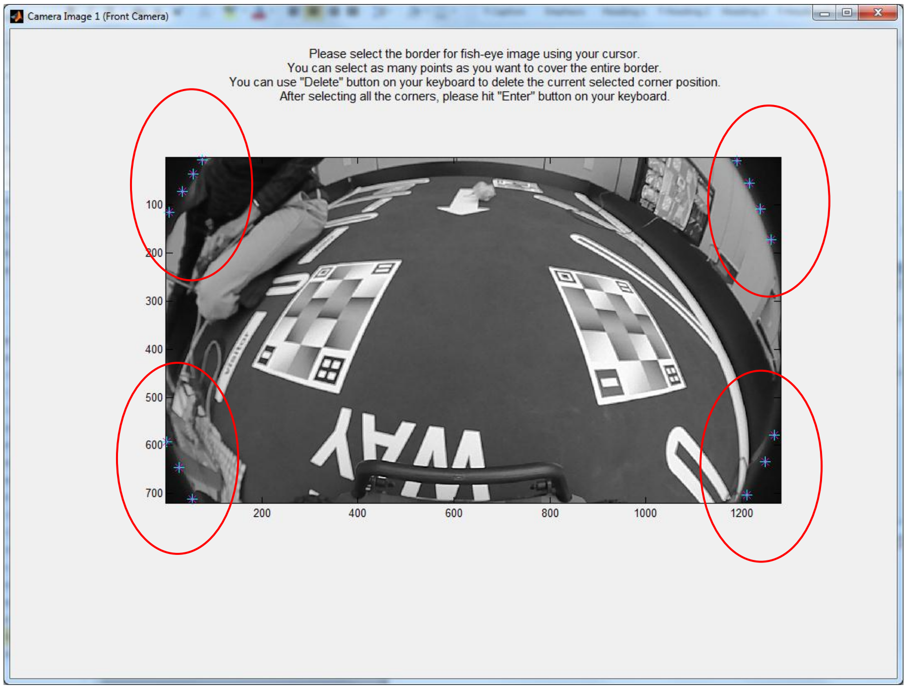
Figure 18 – Fisheye Tool starting window

2. Select the fish-eye view boundaries in each input frame

   You will be asked to select points which represent the border of the fish-eye image. The border means the boundary between the fish-eye image and the black area around the four corners of the image. You can see an example in Figure 19. You may select as many points as you want to around the dark boundary encompassing the fish-eye view.

   At the region where you are more confident about the dark boundaries, you may click more points. At the region where you are less confident, you may select fewer points.

   You will repeat this process for all 4 input camera frames.



Please select the border for fish-eye image using your cursor.
You can select as many points as you want to cover the entire border.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

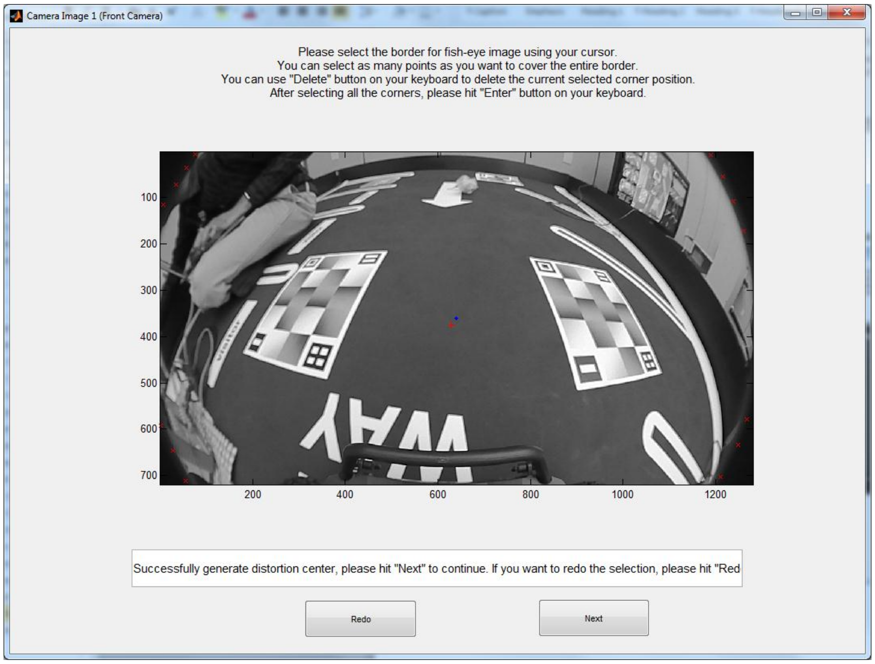
Figure 19 – Select points along the border of fish-eye image, as highlighted by the red circles

After selecting the points, hit "Enter" on your keyboard.

You can then hit "Next" to continue.

If you are not satisfied with the selections, you can hit "Redo" to redo the selection as shown in Figure 20.

You will also see all the selected points and the estimated distortion center of the frame (red cross) together with the frame center as a reference (blue cross). You can see the distortion center may be different from the geometric center of the frame. So it is very important to use the tool to estimate the actual fish-eye distortion centers.

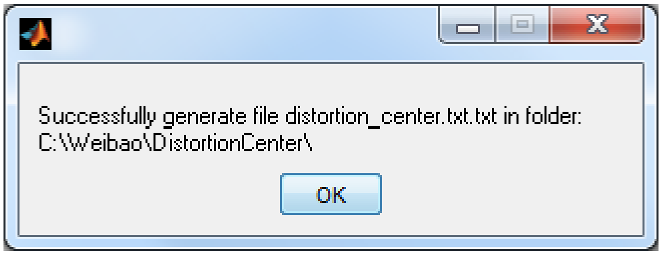


Please select the border for fish-eye image using your cursor.
You can select as many points as you want to cover the entire border.
You can use "Delete" button on your keyboard to delete the current selected corner position.
After selecting all the corners, please hit "Enter" button on your keyboard.

Successfully generate distortion center, please hit "Next" to continue. If you want to redo the selection, please hit "Red

Figure 20 – Selected points and distortion center

3. Finally, you will get a message saying that you have successfully gone through the process. You will find two output files (.txt and .csv) in your selected output folder. You can then use the .txt file for your CalibrationTool to generate the initial perspective matrices as file. The .csv file is needed for the SurroundView.exe demo PC code.



Successfully generate file distortion_center.txt.txt in folder:
C:\Weibao\DistortionCenter\

Figure 21 – DistortionCenterTool finished message

5 Update Vision SDK with New Initial Perspective Matrix and Fish-eye Distortion Centers

After using the calibration tool described in Sec 3 and/or fish-eye distortion center tool in Sec 4, please update the respective files under the vision_sdk folder “.\vision_sdk\vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\” as below.

1. After using Calibration tool (Sec 3), you will get a file called InitialPerspectiveParams.c.
2. After using the Fish-eye distortion center tool (Sec 4), you will get a .txt file with the distortion centers for all four cameras.

- For TDA2x, Open the file, vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignExt_tda2xx.c. Update the persmatin[] & InCamFrmDistortionCen[] with the newly generated persmatin & distortion centers values.

- For TDA3x, Open the file, \vision_sdk\examples\tda2xx\src\alg_plugins\surroundview\GAlignExt_tda3xx.c. Update the persmatin[] & InCamFrmDistortionCen[] with the newly generated persmatin & distortion centers values.

3. Save all changes, compile vision sdk.

6 Revision History

Version #	Date	Revision History
00.10	28/Feb/2014	First draft
00.20	05/Mar/2014	Addressed review comments from team
00.30	23/May/2014	Add manual on how to use calibration tool to generate calibration
00.31	29/May/2014	Updated Sec 2.4.1, added requirement for capturing a reference bird-eye view in addition to dumping four input frames
00.32	2/June/2014	Updated Sec 3 on the requirement for input images for using the calibration tool
00.33	3/June/2014	Updated Sec 4 on selecting input file for distortion center
00.40	5/June/2014	Add DistortionCenterTool
00.41	10/June/2014	(1) updated manual (2) added Sec 5 for updating vision sdk after obtaining new fish-eye distortion center and initial perspective matrix
00.42	25/June/2014	Update reference image for checkered print outs placement
00.43	17/July/2014	Updated both the calibration tool and the manual accordingly In the tool, added "car box sizes" as input parameters to the tool
00.44	11/Aug/2014	Updated sec 2.4.1 on placing the calibration charts
0.50	1/Oct/2014	Updated instructions for Sec. 3 and Sec 4. to reflect that tools output two files (.txt & .cvs in Sec 4, .c & .csv in Sec. 3). Tools now require MCR 8.3, not 8.2 (Mueller)
0.51	4/Feb/2015	Default values of carbox width and height in calibration tool were changed from 240 to 160 and from 360 to 320, respectively, to match changes in VSDK code. No changes needed in this document. (Mueller)
0.52	27/Apr/2015	Added parameters Camera Image

		Height, Width and Pitch to Calibration and Fisheye Tool GUIs and this document. (Mueller)
0.53	20/Aug/2015	Corrected names of executables of calibration tool (calibration_tool.exe) and fisheye lens distortion correction tool (fisheye_tool.exe) in Sections 3.4 and 4.4 (Mueller)

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