ViSiON research

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when it's too fast to see, and too important not to.°

FOR THE MOST CURRENT OF TH

MEASUREMENTS

MEASUREMENTS APPLICATIONS:

Applications that benefit most from the measurement tools include:

- Deployment velocity, acceleration, and position of airbags and crash test dummies
- Military test ranges
- Drop tests to find critical errors such as construction weaknesses
- Fluidic tests
- Biomechanics
- Any applications where measurements need to be performed.

INTRODUCTION:

High-speed motion analysis has been a primary tool to measure moving objects by the defense, scientific and research, and industrial communities for decades. Using the 2-D motion analysis tools incorporated in our PCC (Phantom Camera Control) software essentially turns your Phantom camera into an extremely effective test instrument, as much of an engineering tool as an oscilloscope, spectrum analyzer, or logic analyzer. The photographic technique enables us to visualize and analyze motion, especially motion that is too fast for the human eye or conventional cameras to perceive.

Vision Research understands that any motion analysis tool must be easy to use, without sacrificing the ability to extract and quantify motion from a file.

With our PCC measurement features, the end-user can easily calculate timing, position, distance, velocity, angle and angular speed measurements, and track multiple points or objects to compute and graph their XY-coordinates, speed, or acceleration.



Figure 1: PCC Multi-Layer GUI (Graphical User Interface) automatically tracks head, shoulder and chest to calculate, path, speed, and acceleration.



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Measurements

The ability to perform these calculations with a few clicks of a mouse button; engineers, science and researchers, and developers will significantly reduce research and development time thereby increasing productivity. Providing them with the ability to conduct even more precise and accurate analysis of ballistics, explosions, weapon's development, trajectory, biomechanics, sport performance, flow analysis, crash, combustion, and stress studies, just to mention a few.

These measurement tools provide a motion analysis system that harmonizes measured data with images.

MEASUREMENT APPLICATIONS

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- Deployment velocity, acceleration, and position of airbags and crash tests
- Military test ranges
- Drop tests to find critical errors such as construction weaknesses
- Fluidic tests
- Biomechanics
- Any applications where measurements need to be performed.

HOW TO PERFORM TIMING MEASUREMENTS:

To perform timing measurements accurately, a time stamp (date and time) is embedded into the metadata of every frame captured by the Phantom camera. The time stamp clock source can be the Phantom Control Unit computer's clock, an IRIG-B clock, or a GPS clock (camera dependent).

PCC calculates the time difference between two user-specified frames (start / end of event) or from the captured image being displayed to the trigger (t_0) frame.

- 1. Under the 'Play' tab open the 'Frame Info' selector. PCC automatically displays the the following timing measurements:
 - Time indicates the absolute time (timestamp) the image displayed in the 'Playback' panel was recorded.
 - Interval indicates the frame duration (in micro-seconds) of the image displayed in the 'Playback' panel,.
 - Exposure indicates the exposure time the image displayed in the 'Playback' panel was recorded at.
 - Elapse Time from Trigger calculates the time difference of the image displayed in the 'Playback' panel to / from the trigger (t₀) frame. If a trigger signal is detected in the middle of the t₀ frame, the t₀ frame indicates the

 Time
 00:05:33.042 912.60 Sat Jan 01 2000

 Local
 ▼

 Interval
 1 000 μs

 Bapsed Time from
 0 μs

 Trigger
 2 108 μs

 Image#
 0

V Frame Info

Figure 2: Frame Info selector information fields.

time difference from the absolute time of trigger signal detection to the time the $t_{\mbox{\tiny 0}}$ frame was time stamped.

• Elapse Time from Image# - calculates the time difference between a user-specified frame in the 'Image#' data entry field to / from the image displayed in the 'Playback' panel (typically used to measure the duration of an event (start / end).

HOW TO DEFINE UNITS OF MEASUREMENT

Units of Measurement specify the computing and reporting unit for distance, speed, acceleration, angle, and angular speed measurements.

- 1. Under the 'Manager' tab click the 'Application Preferences' button.
- In the 'Preferences > Measurement' tab click the down-arrow to the right of each of the 'Unit' fields, and select the desired measurement 'Unit' from the pull-down selection list, or
- 3. Click one of the 'Preset' buttons to set a predefined set of units.
- 4. Disable the 'Unique scale per application' if the measurement scale you define will vary from Cine-to-Cine.
- 5. Enable the 'Auto advance to next image during collect points' if you want the Cine to automatically advance to the next image once all the collect points have been manually specified on the displayed image.
- 6. Enable the 'Auto update graphics during collect points' if you want a track point trace, for each point, to be displayed during 'Collect Point' tracking.
- 7. Click the 'OK' button to accept the specified parameter and close the 'Preferences' dialogue window, or 'Cancel' to disregard any changes and close the Preferences dialogue window.

HOW TO DEFINE A MEASUREMENT SCALE

Since a Cine is typically recorded and viewed at some reduction in size to the original scene, establishing a measurement scale is required to set a specified number of pixels in the image equal to a scale unit size, such as millimeters, meter, inches, feet, or pixels. Once created, all measurements are computed and displayed using the scale unit. If no measurement scale exists, the default scale will be 1 pixel = 1 pixel.

General	Measurement	Logging	Camera	
Units				
Distance Unit:	Inches		Presets:	
Speed Unit:	Feet per Second		U.S. Units	
Acceleration Unit:	Feet per Second per Second		S.I. Units	
Angle Unit:	Degrees 👻]	
Ingular Speed Unit: Degrees per Second -				
Other Options Unique scale per i Auto advance to r	application next image during o	collect points		
Auto update grapi	nics during collect p	points		
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Figure 3: Measurement 'Preferences' dialog window.

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Measurements

▼ Measurements Calibration
Calibrate Scale: 0.107 in/pix
Set to all
Calibration done
Axes
Show Coordinates in in
Set Origin Default Origin
Instant Measurement
Distance & Angle & Speed: Origin + Tpoint -
Report File path:
Querry for comments
Result:
Collect Points
Active
Autotracking Update template
File path: Save File
C:\Program Files\Phantom\Cines\ PPF: 3
Current point: 0 ~ X Options

Figure 4: Measurement selector options.

- 1. Under the 'Play' tab open the 'Measurement' selector.
- 2. Click the Calibrate button.
- 3. A status line, just below the 'Calibrate' button, prompts to 'Click the first of gauge or enter a scale value'. Basically, the system is asking to mark one end of a known scale. Click that point on the image displayed in the 'Playback' panel, or enter a scale value in the 'Scale' data entry field.
- 4. Next, the status line prompts to 'Click the second end of the gauge'. This time the system is asking to mark the opposite end of the known scale. Click that point on the image being displayed in the 'Playback' panel.
- 5. In the 'Set Gauge' dialogue enter the 'Gauge' (length of scale), and click the 'OK' button. The gauge length is a known dimension of any object or space in the image. It is always better to select a larger object in the image for the gauge process. The scale field and status line under 'Calibrate' button provide information about the calibration. PCC will apply this calibration to the entire Cine, and any image extracted from the Cine.
- 6. Optionally, Click the 'Set to All button' to apply the calibration defined in the previous steps to all open Cine files, (Cine files being displayed in their own, individual, 'Playback' panel).

HOW TO SET AN ORIGIN POINT

By default, the PCC software identifies the first pixel, located in the upper left image corner of the 'Playback' panel, as the origin point to perform 'Coordinate, Distance, Angle, Speed, or Collect Point (Tracking) measurements. The choice of origin will be largely dependent on the subject and the type of motion being studied.

- 1. With the 'Units of Measurement' and 'Calibration' defined, use the video control buttons to locate the first image (frame) of the clip measurements are to be performed on.
- 2. Under the 'Play' tab > 'Measurement' selector enable the 'Show' option to view the position of the defined origin axes.
- 3. Click the 'Set Origin' button.
- 4. Move the cursor desired point-of-origin and click the left mouse button. PCC overlays the displayed image with a blue cross hair. Its' center point indicates the newly set 'Origin'.
- 5. To reset the 'Origin' back to the default position, the first pixel of the image (the upper left-hand corner pixel), click the 'Default Origin' button.

HOW TO PERFORM COORDINATE MEASUREMENTS

Coordinate measurements are calculated from an Origin point pixel. However, the Origin can be changed when performing measurements. Each coordinate consists of two numbers (x1, y1) indicating the position of a pixel, in the image, on the two-dimensional plane from the Origin point.

- 1. With the 'Units of Measurement', 'Calibration', and 'Origin" defined, use the video control buttons to locate the first image (frame) of the clip measurements are to be performed on.
- Under the 'Play' tab > 'Measurement' selector enable the 'Coordinates in [distance unit]' option.
- 3. Move the cursor to the desired coordinate point to be measured in the image displayed in the 'Playback' panel.
- 4. The x,y coordinates of the pixel, in the center of the cross-hair cursor, will be displayed in the 'Status Bar' ('Preview / Playback' display area).

HOW TO PERFORM DISTANCE, ANGLE, SPEED MEASUREMENTS

PCC can measure the distance from a user-specified 'Origin' point to a selected point, and the angle made by the Origin and Ox axis of the selected point using the' Distance and Angle and Speed: Origin+1Point' instant measurement tool. If the 'Origin' and the selected point are on the same image, PCC will calculate distance and angle only; however, if the 'Origin' and the selected point are on different frames, the software also calculates speed and angular speed.

If the is no 'Origin' (reference) point in the frame distance, angle, and speed measurements can be accomplished using the 'Distance, Angle, Speed: 2Points' instant measurement tool in PCC.

With either method, all measurement points can be logged into a comma separated text file that can be exported to a text editor or word processor program, like Microsoft Excel, to generate a report file.

These measurement tools are exceptional when analyzing a displacement, velocity, trajectory, or rotation of objects

- 1. With the 'Units of Measurement', 'Calibration', and for Distance, Angle, Speed: Origin+1Point only the 'Origin' defined, use the video control buttons to locate the first image (frame) of the clip measurements are to be performed on.
- Under the 'Play' tab > 'Measurement' selector enable the 'Show' option to view the position of the defined origin axes if the Distance, Angle, Speed: Origin+1Point tool is being used, if not skip this step.

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- 3. Enable the 'Active' command in the 'Instant Measurement' group.
- 4. Click the 'Select Measurement' pull-down selection list and select the desired 'Distance, Angel, Speed' instant measurement tool required to calculate measurements (see graphical representations below).

Figure 5:



Distance, Angle, Speed: Origin+1Point; (left) Distance, Angle, Speed: 2Points (right) graphical representation.

- 5. If a report file is to be generated or re-opened for the measurements, click the '...' button under the 'Instant Measurement' options; navigate to the folder the file is to be saved at, enter the filename for the report file in the 'File name:' data entry field, then click the Open button.
- 6. For applications where the Origin point can be referenced place the cursor over the center of the 'Origin (0) point and mouse click to mark it'; for application where an Origin can not be referenced mark a reference point (Pt.1).
- Next mark the point (Pt.1) to be measured from the Origin for 'Distance, Angle, Speed: Origin+1Point' measurements, or select the point (Pt. 2) to be calculated from the reference point for 'Distance, Angle, Speed: 2Points' measurements.
- 8. If the 'Querry for comments' option is enabled, enter (up to 40 characters) a comment, about the measurement just taken, that will be added to the report file.
- 9. After all the points have been marked, PCC instantaneously calculates and displays its findings in the 'Results' field. If the origin or reference points are on the same image with the points being measured, PCC calculates distance (d=) and angle (a=) only. If the origin or reference points are on different images than the points being measured, PCC not only calculates distance (d=) and angle (a=) but also calculates speed (s=) and angular speed (as=).
- 10. When finished uncheck the Instant Measurement 'Active' command.

HOW TO PERFORM ANGLE & ANGULAR SPEED MEASUREMENTS

The 'Angle & Angular Speed: 3Points' instant measurement tool calculates the angle made by three points (two lines with a common reference point) while 'Angle & Angular Speed: 4Points' calculates the angle formed by four points [Pt.1 Ref.1 and Ref.2 Pt.2] two lines without a common reference point.

Like the Distance, Angle, Speed instant measurement tools, either method can log all measurements points into a comma separated text file that can be exported to a text editor or word processor program, like Microsoft Excel, to generate a report file.

These measurement tools are exceptional when analyzing a rotating object.

- 1. With the 'Units of Measurement' and 'Calibration' defined, use the video control buttons to locate the first image (frame) of the clip measurements are to be performed on.
- 2. Enable the 'Active' command in the 'Instant Measurement' group.
- Click the 'Select Measurement' pull-down selection list and select the desired 'Angel & Angular Speed' instant measurement tool required to calculate measurements (see graphical representations below).



Angle, Angular Speed: 3Points (left); Angle, Angular Speed: 4Points (right) graphical representation.

- 4. If a report file is to be generated or re-opened for the measurements, click the '...' button under the 'Instant Measurement' options; navigate to the folder the file is to be saved at, enter the filename for the report file in the 'File name:' data entry field, then click the Open button.
- 5. Place the cursor over the center the point that will represent the x-axis point (Pt.1) of the angle and click the mouse to mark it.
- 6. Mark the point(s); for 'Angle & Angular Speed: 3Points' measurements mark the center of the reference (Ref.) point. For 'Angle & Angular Speed: 4Points' measurements, mark the reference (Ref.1; Ref.2) points.
- 7. Mark the point, for 'Angle & Angular Speed: 3Points', that represents the reference (Ref.) point of the angle. Since the is no absolute reference point for 'Angle & Angular Speed: 4Points' mark the first reference (Ref.1) point, then mark the second reference (Ref.2) point to create a virtual reference point.
- 8. Mark the measured (Pt.2) point.
- 9. If the 'Querry for comments' option is enabled, enter (up to 40 characters) a comment, about the measurement just taken, that will be added to the report file.
- 10. After all the points have been marked, PCC instantaneously calculates and displays its findings in the 'Results' field, as follows:

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- a. If all the points are on the same image PCC calculates angle (a=) only.
- b. For 'Angle & Angular Speed: 3Points' PCC calculates angle (a=) and angular speed (as=) for the following sceneries:
 - Pt.1 and Ref. points are on one image; Pt.2 on another
 - Pt.1 is on one image; Ref. and Pt.2 are on another
 - Pt.1, Ref. and Pt.2 are on separate images
- c. For 'Angle & Angular Speed: 4Points' PCC calculates angle (a=) and angular speed (as=) if Pt.1 and Ref.1. points are on one image, and Ref.2 and Pt.2 are on another.
- 11. When finished uncheck the Instant Measurement 'Active' command.

HOW TO PERFORM COLLECT POINT (TRACKING) MEASUREMENTS

PCC also provides a Collect Point (tracking) tool to compute the position, speed, acceleration, along with the ability to generate report files and motion graphs of a point (or object) or multiple points (up to 99), with respect to the image plane, over time. The analyst can use one of two methods to track 2D motion (Automatic or Manual).

Automatic 'AutoTracking' finds the position of a point in subsequent images after defining its position in the first image automatically. 'AutoTracking' is accomplished during the playback of the Cine. It is very important that the images be in succession; Auto tracking will self-disable if they are not. To avoid this the 'Plays Speed & Options > Play each image' feature is forced on. 'AutoTracking' will also self-disable when jumping from the last image to the first. However, the points will remain attached to those areas in the image as they are stored in the collect point (.pps) file. You can reopen the Cine and collect point file to have the points overly on image or export to a comma separated text editor or word processor program like Microsoft Excel.

- 1. With the 'Units of Measurement', 'Calibration' and 'Origin' defined, use the video control buttons to locate the first image (frame) of the clip measurements are to be performed on.
- 2. Click on the '...' button to the right of the 'File Path' data entry field to create or open a collect point (.pps) file containing the coordinates of the collected.
- 3. In the Open dialogue window navigate to the folder the collect point file is to be or has been saved enter the filename of the collect point file in the 'File Name' data entry field, and click on the 'Open' button.
- 4. Under the 'Collect Point' selector options define number of points (99 maximum) to be collected in the 'PPF:' (Points Per Frame) field.

- 5. Using the video control buttons locate first frame with point(s) to be tracked and enable 'Collect Points'.
- 6. Click the center of the point(s) you want to track on the image displayed in the 'Playback' panel.
- 7. To delete a point, select the point from the 'Current Point' pull-down selection list, then press the 'X' button.
- 8. To relocate a point, select the point from the 'Current Point' pull-down selection list, then reset the point in the image.
- 9. Define the tracking parameters for each point by selecting the point to be defined from the 'Current Point' pull-down selection list, and click the 'Options' button.
- 10. In the Options dialogue window enable 'Autotrack Active'. This option selectively enables / disables the AutoTrack feature for the point being defined.
- 11. Enable 'Show Rectangles' to displays the 'Target Area' and 'Search Area' regions for all point(s) being tracked. The area sizes are defined by the 'Template Area Size' and 'Search Area Size' parameters.
- 12. Enable 'Draw Point Trajectory' to display a tracking trace, in the tracking 'Graph', for the specified point(s).
- 13. Specify the 'Template Area Size' to define the width and height (in pixels) of the of the point being tracked (defined in the first image and searched for in subsequent images). The initial mouse click of the point selected define its center.
- 14. Specify the 'Search Area Size' to define how large of an area to search, in the next image, for template image matches. Essentially it is a percentage of the defined 'Template Area Size'. A value equal to the 'Template Area Size' indicates that the tracking algorithm should search in a region as large as the initial template image region size. Larger values will result in larger search areas, which will take a longer time to search.

Typical values for these parameters are two to three times the size of the initial image template (defined in pixels).

- 15. Specify the 'Tracking Sensitivity' to define the acceptable level of difference between the template and the occurrence in the new image. A strict matching algorithm is used to avoid false matches; however this may lead to more frequent loss of targets during tracking. To compensate for this, you can adjust the 'Tracking Sensitivity' to be more tolerant.
- 16. The 'Template Image' displays an image of the tracking template. Templates can be dedicated markers (crosses, quarter of circles in opposition black-white, white-black) or any objects in image that has something different on

oint 0 Op	tions			23
 Autotr Show Drew Templat 	ack active rectangles point trajec e area size	e s ctory		
Width:	15	Height:	15	pix
Search	area size			
Width:	30	Height:	30	рік
Tracking	g Sensitivit	v		
0.75	Tolerant	· · · ·	1.1.1	Strict
Template	image:			
Set to a	al points]		

Figure 7: Collect Point 'Options' dialogue window.

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two orthogonal directions. The middle of the straight line is not good but an isolated spot, a corner or an angle are acceptable. To view the image enable 'Autotracking' under the 'Collect Point' options.

- 17. Optionally click the 'Set to All Points' button to apply the above settings to all currently selected points.
- 18. Close the 'Point Options' dialogue window.
- 19. Under the 'Collect Point' options enable 'Auto-tracking'.
- 20. Optionally enable 'Update Template' due to rotations, shadows, etc. the point can be lost. If auto update is disabled PCC will allow the selective disabling of the feature.
- 21. Click the 'Graphics' toolbar button to view tracked point values.

In the event a tracked point is lost:

- 22. Rewind the Cine until the point re-appears.
- 23. Step to the next image.
- 24. Select the point from the Current Point pull-down selection list.
- 25. Reselect the point in the image.
- 26. Re-enable Auto-tracking.
- 27. Play the Cine.

Collect Point, Speed, Acceleration report file generation:

- 28. Deactivate Collect Points upon completion.
- 29. Click the Save button to save the Points file or create Speed / Acceleration Report files. If the 'Points' file is not saved PCC will display 'There is unsaved data for Collect Points file path<file name>' 'dialogue window when the application is closed.
- 30. In the Save Speed or Acceleration dialogue window navigate to the folder the Speed / Acceleration file is to be or has been saved.
- 31. Enter the filename of the Speed File in the File Name entry field.
- 32. Click on the Save button.

Manual tracking requires the analyst to select every point being tracked for each frame.

With either method all tracked points are logged in a measurement file that can be used to generate a coordinate, speed, or acceleration commas separated text file easing report generation.

HOW TO USE GRAPHICAL DISPLAY

By default the chart displays a graph of all measurement values for all collected track points specified by the user in the 'Play > Measurement > Collect Points' selector. The software assigns each tracked point a unique color. The numbers below the chart are the frame numbers of the Cine file, the numbers to the right represent the tracked point values (defined in the 'Manage r> Application Preferences > Measurement > Units options). The green line, visible in the zoomed view, represents the position of the trigger frame; the white line is the current frame position. The dots are the tracked points. Placing the cursor over a tracked point displays the following information:

- im (image) indicates the image number the specified reference point of the signal is associated with.
- point (number) indicates the associated tracked point value dependent on the chart type (position / speed / acceleration).



- Figure 8: Collect Point Graph displaying three x-coordinate points (left); zoomed view (right).
- 1. Click the' Points' pull-down selection list to select the 'Tracked Point(s)' to be displayed (by default all tracked points are displayed).
- Click the 'X' or 'Y' pull-down selection list and select the coordinate (X / Y) of the 'Tracked Point(s)' to be displayed.
- 3. Click the 'Position' or 'Speed' or 'Acceleration' pull-down selection list and select the type of chart to display.

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- 4. Click 'Show Values' / 'Zoom' pull-down selection list to:
 - a. Show Values used to display a collect point value by moving the cursor over the point in the chart.
 - b. Window / Horizontal / Vertical Zoom used to drill down into the graphical display to view measurement points.
 - c. Zoom In Around Point / Zoom Out Around Point used to zoom in to / out of the display by holding down the left mouse button until the desired level of zoom is reach or right mouse click on display and select the 'Zoom In / Out Around Point one time.
 - d. Pan moves the chart around by holding in the left mouse button and moving the mouse in the direction you wish to move the chart.
- 5. Click 'Fit' to resets the display window to its' original size to display the entire signal range for all frames.
- 6. Click 'Center Current Frame' to center the chart so the current frame is displayed in the center of the chart.
- 7. Click 'Save' to create a comma separated text file and select the type of file to be saved from the pull-down selection list:
 - a. All creates a report file for all the analog channels visible or not.
 - b. Visible creates a report file for the visible analog channels only.
- 8. In the 'Save Signal(s)' dialogue window navigate to the folder the report file is to be saved to.
- 9. Enter a filename for the report file being saved in the 'File name:' field (software will automatically add the .cvs file extension).
- 10. Click 'Save' to create file; 'Cancel' to abort.

Focused

Since 1950, Vision Research has been designing, and manufacturing high-speed cameras. Our single focus is to invent, build, and support the most advanced cameras possible.





100 Dey Road Wayne, NJ 07470 USA +1.973.696.4500

www.phantomhighspeed.com