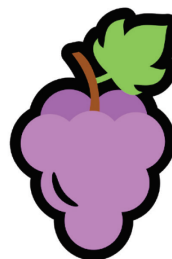


GRAPE™ USER MANUAL

Version 4



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May 31, 2022

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Contents

1	About Grape	3
2	Installation	3
3	What is new in Version 4	3
4	Introduction	3
4.1	<i>General</i>	3
4.2	<i>Features</i>	4
4.3	<i>Quick start</i>	4
4.4	<i>Grape execution timeline</i>	4
4.5	<i>The sequence</i>	5
4.6	<i>Service files</i>	6
5	Grape alignment aids	6
6	Grape job	8
6.1	<i>Creating the job</i>	8
6.2	<i>The job parameters</i>	9
6.2.1	Horizontal printing density	9
6.2.2	Vertical printing density	9
6.2.3	Measured pitch	10
6.2.4	Picture sizes	10
6.2.5	Margin height	11
6.2.6	Alignment patterns position	11
6.2.7	Direction	12
6.3	<i>The job file</i>	12
7	Grape execution	13
8	The interlaced image	13
9	Notes	13
9.1	<i>Horizontal printing density constraint</i>	13
9.2	<i>Paths</i>	14
9.3	<i>Saving the interlaced image</i>	14
9.4	<i>Links</i>	14
9.5	<i>Grape icon credits</i>	14
10	Bibliography	15

1 About Grape

Grape converts a lenticular sequence to an image for lenticular print. It is based on algorithms described in the “Lenticular Imaging” book (Weissman, 2018).

Grape is provided free of charge under the GNU general public license ver. 3 (GPL 3, <https://www.fsf.org/>).

2 Installation

Download the archive from the Pop3Dart website and extract its contents. The contents should include Grape.exe, demo sequence folder, demo job file, and a license file. Create an empty folder and copy these files to it.

You can move/copy Grape.exe to any place on your hard drive and launch it from there.

Grape for Windows runs on Windows 64-bit machines.

Grape for MacOS was tested on Big Sur.

3 What is new in Version 4

- Improved memory management. With a given amount of memory, Grape can process now larger images than before.
- Improved centering. The center alignment pattern can be used now for precision centering.
- Migration. Grape.exe can be now freely moved around and launched from anywhere in your storage.
- Sequence numbering. Now Grape supports sequence images numbering in lexicographic format in addition to common numbering.
- Compatible with MacOS. Note: upon first launch, Mac OS may block Grape for security reasons. To open it anyhow, right click on the app and choose ‘open’.

4 Introduction

4.1 General

Grape converts a sequence of images to a single printable image ready for a lenticular picture. This conversion consists of two main steps:

1. Interlacing
2. Calibration

Interlacing is a process that converts a sequence of images to a single image. Calibration adjusts the interlaced image so that when it is printed, it is matched to the measured lens pitch. Both steps are discussed in detail in the “Lenticular Imaging” book (Weissman, 2018).

The operational block diagram of Grape is shown in Figure 1.

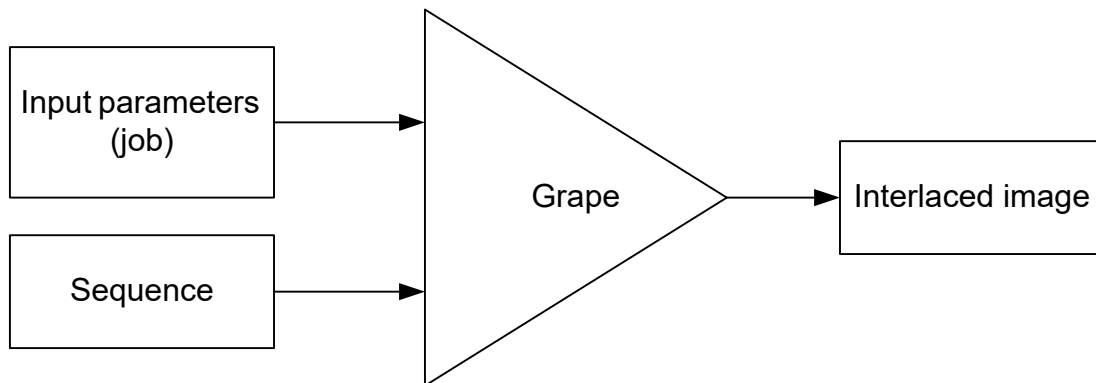


Figure 1: Grape operation block diagram

The sequence must be prepared before launching Grape, as described below.

4.2 Features

- Simple and fast
- Picture size limited only by computer memory
- Supports different printing densities in the horizontal and the vertical directions
- Prints alignment margins to facilitate orientation and centering adjustments
- Centered calibration (image center remains intact)

4.3 Quick start

You can use the included demo files to run an example immediately. Launch Grape, open the demo job, submit it, choose the demo sequence directory, and then save the output.

4.4 Grape execution timeline

To launch Grape, double-click on 'grape.exe'. The execution starts 6 to 10 seconds after the launch.

There are five main steps in the execution:

1. Job definition
2. Interlace
3. Add alignment margins
4. Calibrate
5. Save

The job definition step is discussed in Chapter 5 below. As soon as the job is submitted, a runtime window appears on which the processing steps are

displayed. In addition, this window displays two buttons (Figure 2). You can launch a new job with the “New Job” button or exit Grape with the “Quit” button.

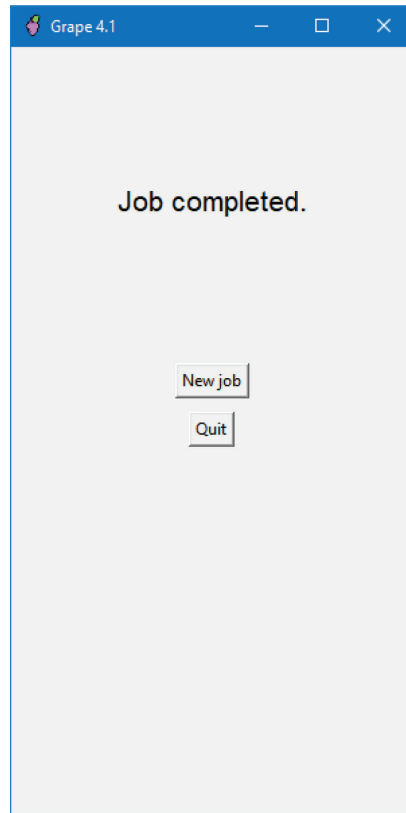


Figure 2: Completed job window

4.5 The sequence

The sequence must be stored in a single folder.

All sequence images must have identical pixel sizes and RGB format (not CMYK). The file names must be a sequence of integers.

If the first image name is '1', then the image names must be '1', '2', '3', ...

If the first image name is '01', then the image names must be '01', '02', ...'10', '11', ...

If the first image name is '001', then the image names must be '001', '002', ...'010', '011', ...'100', '101', ...

If there is no image with either of the names '1', '01', or '001', an error is raised.

The contents of the demo sequence folder are shown in Figure 3 as an example.







Name	Date	Type	Size
 1	2/3/2020 10:15 AM	JPG File	158 KB
 2	1/14/2020 10:50 AM	JPG File	158 KB
 3	1/14/2020 10:50 AM	JPG File	157 KB
 4	1/14/2020 10:50 AM	JPG File	158 KB
 5	1/14/2020 10:50 AM	JPG File	159 KB
 6	1/14/2020 10:50 AM	JPG File	160 KB

Figure 3: The contents of the demo sequence folder

The sequence folder may contain other files. Only image files with the chosen format and names that make a continuous numerical sequence will be recognized as sequence images. For instance, if your folder contains image files '1.jpg', '2.jpg', '3.jpg', '5.jpg', and the chosen format is 'jpg', only images '1.jpg', '2.jpg' and '3.jpg' will be recognized as a sequence.

The sequence folder should be ready before you launch Grape.

4.6 Service files

At first run, Grape will create on your computer a service folder to store two service files. The service folder path depends on the operating system.

On Windows the service folder path is:

'C:\Users\[username]\AppData\Roaming\Pop3DArt\Grape'.

On MacOS the service folder path is:

'/users/[username]/Library/Application Support/Pop3DArt/Grape'.

In each run Grape checks whether the service folder exists. If it is absent, Grape will re-create it.

Grape stores two files in the service folder: Grape_paths.txt and Grape.log.

Grape_paths.txt is used to store the last file paths used by Grape. These paths will be used for the next run to save the user navigation efforts.

Grape.log is another text file that stores the execution log. Here you can find a record of the various execution steps with a time stamp. Any error messages are recorded as well. If you turn to us for technical help concerning Grape execution, be sure to send us the corresponding log file.

The log is overwritten in each run.

5 Grape alignment aids

There are two requirements concerning the alignment of the print to the lens sheet. First, the print vertical edges must be parallel to the lenticules. Second, the print center must coincide with a lenticule center. The alignment precision of

both parameters is a major factor in the picture quality. Grape uses a special pattern to help with this alignment.

There are three alignment patterns in the Grape output image: two adjacent to the vertical edges and one at the center. The picture almost wholly obscures the center pattern, and only its top and bottom edges are visible. The edge patterns may be partially obscured, depending on the choice of the alignment pattern position (see below).

The alignment pattern is a vertical column displaying a black hairline imaged in front of the picture. The print needs to be aligned relative to the lens sheet so that this hairline is parallel to the picture edge. This guarantees parallelism between the printed and the lenticular grids.

The center pattern is used for centering. For this alignment, the picture must be viewed from the center, preferably with a single eye. When the picture is properly centered, the line appears at the center of the center alignment pattern, both at top and at bottom.

The Grape output demo image with the alignment aids is shown in Figure 4. The black line cannot be seen in this figure; it is only seen in the real picture.

The margins are intended to be cut out from the picture after its fabrication.

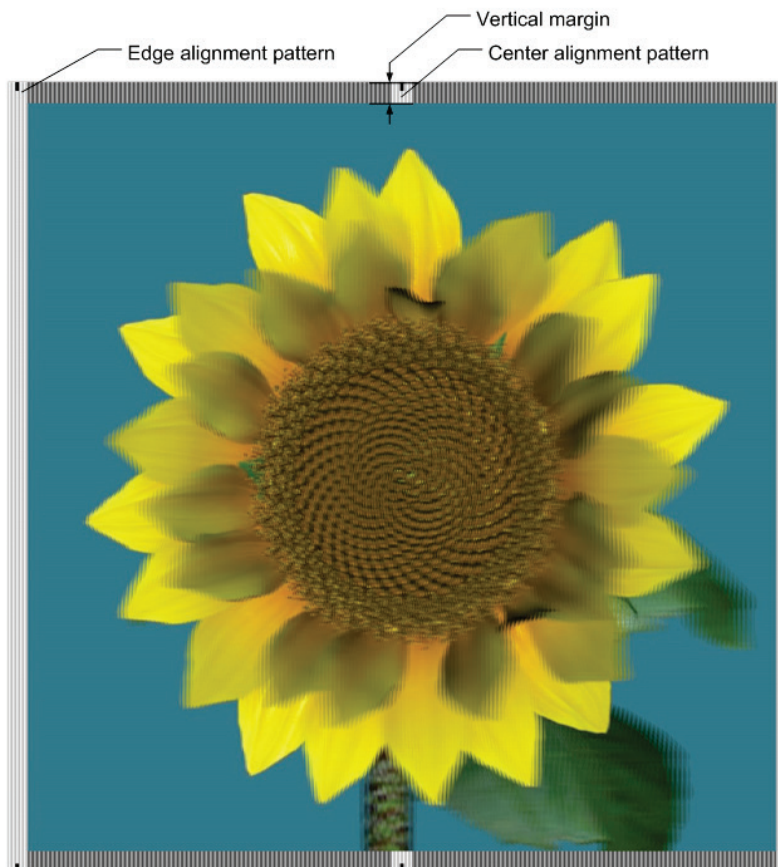


Figure 4: The output image of the demo job and sequence with the alignment aids

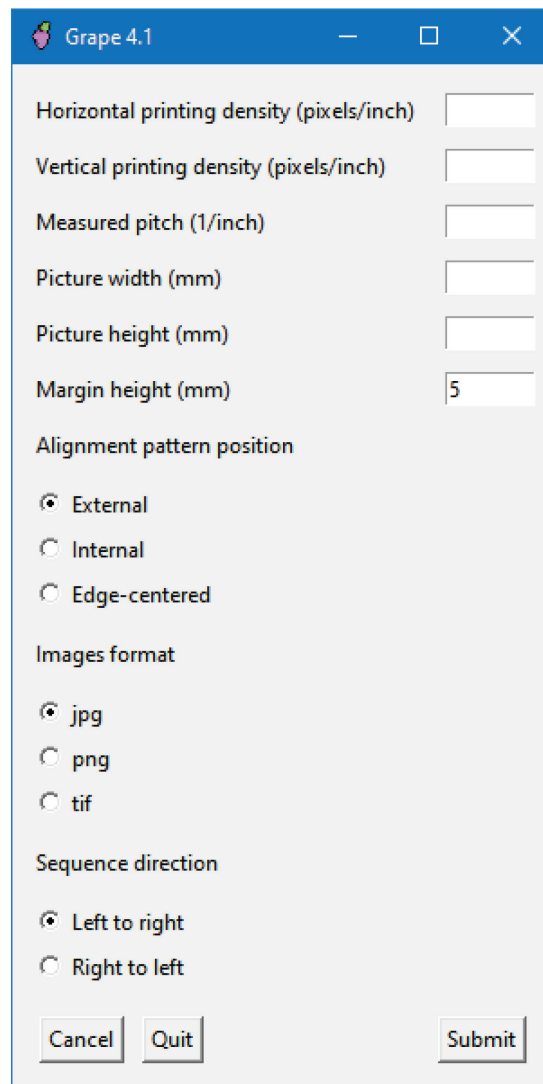
6 Grape job

6.1 Creating the job

Grape needs a set of parameters to create an interlaced image. The parameters and their default values are given in Table 1 below.

You are asked to open a job as soon as Grape is launched. If you have an existing job that you would like to use, you can open it here. This opens the job dialog window, in which the opened job is displayed. You can change the values of the displayed job parameters.

If you do not have a job file, click cancel to open a new job form shown in Figure 5. The job form has 6 numeric fields and three radio buttons groups: 'Alignment pattern position', 'Images format' and 'Sequence direction.' The last numeric field and the buttons groups have default values (see also Table 1). All default values (including the buttons groups) can be changed.



The screenshot shows a dialog box titled "Grape 4.1" with a standard Windows window frame (minimize, maximize, close buttons). The dialog contains several input fields and three groups of radio buttons. The fields are: "Horizontal printing density (pixels/inch)", "Vertical printing density (pixels/inch)", "Measured pitch (1/inch)", "Picture width (mm)", "Picture height (mm)", and "Margin height (mm)" which has the value "5" entered. The three radio button groups are: "Alignment pattern position" with options "External" (selected), "Internal", and "Edge-centered"; "Images format" with options "jpg" (selected), "png", and "tif"; and "Sequence direction" with options "Left to right" (selected) and "Right to left". At the bottom, there are three buttons: "Cancel", "Quit", and "Submit".

Figure 5: The new job form

All numeric fields must be filled. Leaving blank numeric fields will cause an error. The values ranges of the numeric fields are specified in Table 1. Specifying a value out of range will also cause an error.

Once the job form is ready you may press the 'Submit' button. If any value in the form was changed (including radio buttons), you would be prompted to (optionally) save the job.

Pressing "Cancel" discards the current job form and prompts you to open a new job. Pressing 'Quit' will close Grape.

6.2 The job parameters

Table 1: Grape job parameters

Parameter	Name in job file	Parameter meaning	Default value	Values range	Units
Horizontal printing density	hppi	Horizontal pixel density for print	-	(100, ∞)	1/inch
Vertical printing density	vppi	Vertical pixel density for print	-	(20, ∞)	1/inch
Measured pitch	lpic	Measured lenticular pitch	-	(5, ∞)	1/inch
Picture width	fw	Picture net width	-	(10, ∞)	mm
Picture height	fh	Picture net height	-	(10, ∞)	mm
Margin height	marginh	Vertical margin for the alignment pattern	5	[0, ∞)	mm
Alignment pattern position	Alignment pattern position	Species the position of the left and the right alignment patterns	external	-	-
Images format	Images format	The format of the sequence images	jpg	-	-
Direction	Direction	The direction of the images sequence	Left to right	-	-

6.2.1 Horizontal printing density

Specify here the horizontal pixel density that will be used to print the interlaced image. The maximal printing density limits this value that the printer driver can accept. Common maximal values in high-resolution inkjet printers are 2,880 and 2,400 pixels per inch (ppi).

It is recommended to specify for this parameter the highest pixel density that the printer can resolve. This is typically much smaller than the maximal printing density of the printer that can be specified. Unfortunately, real printer resolutions are not specified by the manufacturers. As a rule of thumb, use 720ppi for Epson Stylus printers and 600ppi for Canon and HP printers. Setting a value higher than the printer can resolve can lead to blurring.

6.2.2 Vertical printing density

The visual horizontal resolution element of a lenticular picture is equal to the lenticule width (Weissman, 2018). In the vertical direction, the smallest resolution element is the printed pixel height.

It is common to create interlaced images with equal pixel densities in the horizontal and the vertical directions. This causes the picture pixels to have an aspect ratio equal to the sequence length (Weissman, 2018). In most cases, this results in a tremendous waste of resources, since for typical pictures, there is little to be gained (in terms of visual quality) by using non-square (visual) pixels.

It is recommended to set the vertical pixel density value to approximately twice the used lenticules density ('lpi' value). The user is welcome to experiment with this parameter. Grape allows setting the horizontal and the vertical pixel densities independently.

6.2.3 Measured pitch

This parameter is the measured value of the optical grid cell density (Weissman, 2018), and its units are 1/inch. Typically, this parameter's precision should be four digits, though, in some applications, five digits may be necessary. It should be measured by using a special pattern.

Note: the measured pitch depends on the viewing distance. For an infinite viewing distance, the measured pitch and the lenticular sheet pitch become identical.

6.2.4 Picture sizes

The two picture size parameters (width and height) are specified in mm. Both the picture width and the horizontal margin (see below) are adjusted to contain a whole number of lenticules so that you might expect small deviations in these parameters from the specified values.

It may happen that the specified picture aspect ratio (width/height) does not match the aspect ratio of the images in the sequence. In such a case, the printed picture size will be different from the specified. Grape adjusts the printed picture sizes to be maximal but not to exceed any of the specified dimensions. This is sometimes called "frame-filling".

For example, suppose that the user specified both picture width and height as 200mm, but his images in the sequence have an aspect of 0.5. In such a case, the printed picture size will be 100mmx200mm. This is illustrated in Figure 6.

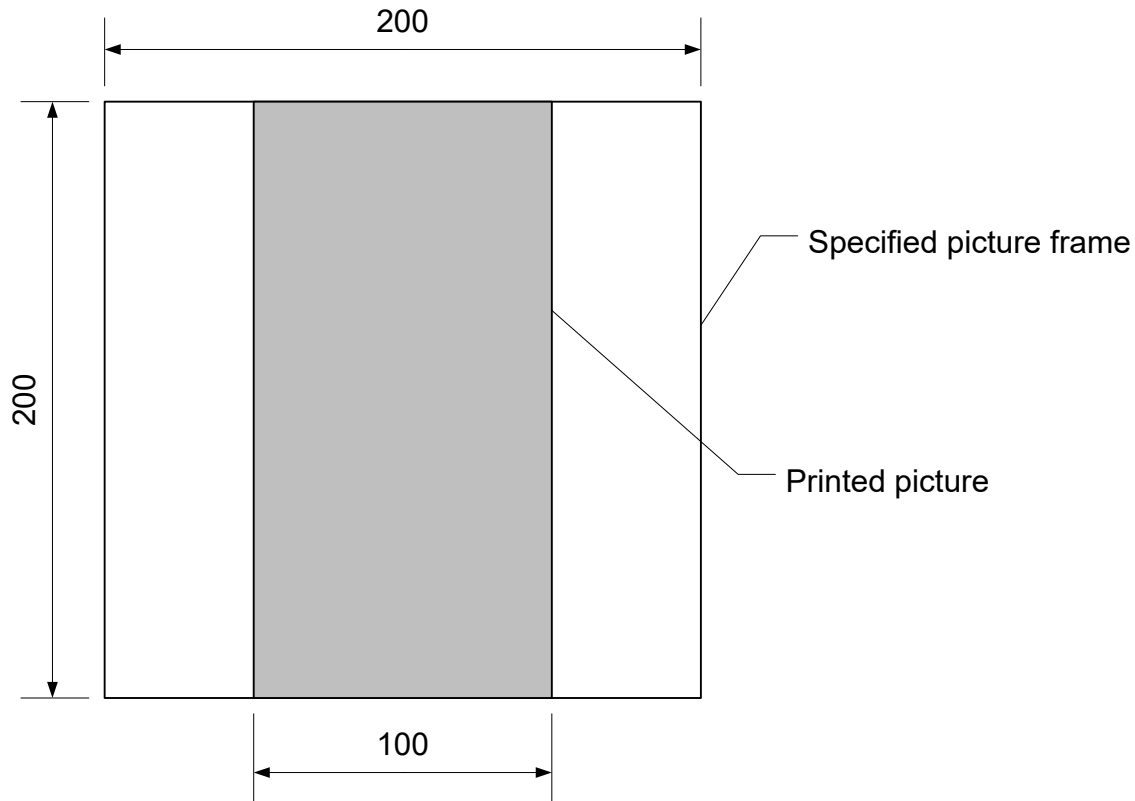


Figure 6: Example of specified and printed pictures

6.2.5 Margin height

The value of the margin height determines the width of the top-bottom banners. This value must be non-negative. Usually, a vertical margin of 5mm is sufficient. If you specify '0' for the margin height the picture will be printed without top-bottom alignment bars.

The top-bottom banners contain the tops and the bottoms of the three alignment patterns (see below). These banners also contain a black-white grid calibrated to the measured pitch. It can be used to verify the picture calibration.

6.2.6 Alignment patterns position

Grape uses margins for printing alignment aids. These alignment aids are special patterns that are used for parallelism and centering alignments of the print with respect to the lenticular sheet. Grape prints three alignment patterns for each picture: at the center (the center pattern) and at the edges (the left-right patterns).

In Grape 4 there are three options for the position of the left-right alignment patterns: external, internal, or edge-centered. In the external/internal options, the alignment patterns are placed adjacent to the printed image edges eternally/internally. In the edge-centered option, the alignment patterns are

centered with respect to the printed image left and right edges. This option can be used for horizontal stitching of lenticular pictures.

Figure 4 shows the output of grape with the 'external' option.

6.2.7 Direction

The basic viewing scenario of a lenticular picture is shown in Figure 7.

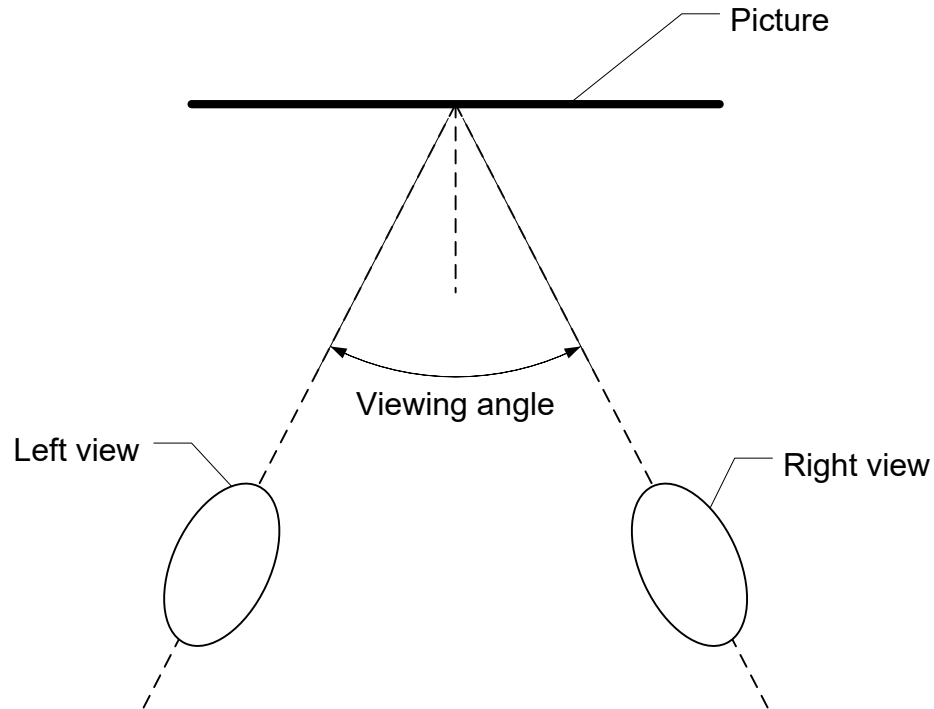


Figure 7: Viewing scenario (from top)

At the edges of the viewing angle (or, more precisely, of the main viewing lobe), the observer will see the first ('1.jpg') and the last ('x.jpg') images of the sequence.

If the observer sees the first image in the right view, the sequence direction is right to left. In the other case, the sequence direction is left to right.

You can specify for the direction parameter any value. If the value is "LR", image '1.jpg' will be displayed in the left view. For any other value, '1.jpg' will be displayed in the right view.

6.3 The job file

The job file is a text file with a separate line for each parameter, a total of 9 lines. Each line has two parts: the parameter name and its value. The two parts are separated by the semi-colon mark ':' The order of the lines is arbitrary, and blanks are ignored. You may open and edit a job file with any text editor. The demo job file is shown in Figure 8. Blanks were inserted after the semi-colon marks to justify the values and improve the readability.

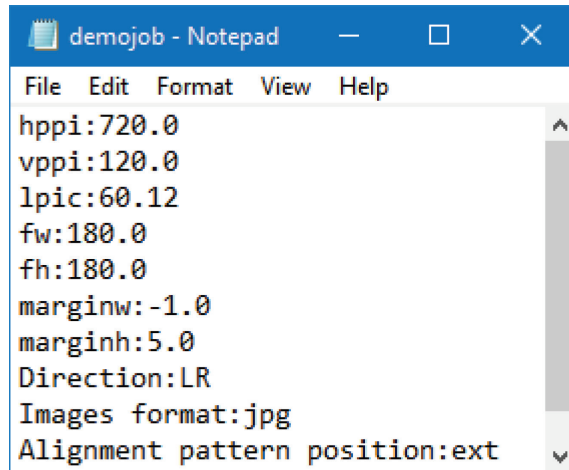


Figure 8: The demo job file

You can create job files with several blank values and use them as 'templates.'

7 Grape execution

Once the job is submitted, Grape opens a dialog for choosing the sequence folder. On Mac, the dialog asks the user to open a sequence image. Any one of the sequence images can be opened. The choice of any particular sequence image does not affect the Grape execution and results.

Grape continues automatically with the execution of the following stages. The Grape window displays messages indicating the current stage.

8 The interlaced image

The interlaced image is saved in 'tif' format and will have the printing density values specified in the job. If the horizontal and the vertical printing densities values are different, the interlaced image pixels will be non-square.

Not all graphical programs can accept images with non-square pixels. A notable example is Photoshop. However, many common programs, like Microsoft Office Document Imaging, accept such images, and print them directly. Another (free) program that can handle such images is Xnview (<https://www.xnview.com/en/>).

9 Notes

9.1 Horizontal printing density constraint

There is one algorithmic constraint concerning the 'Horizontal printing density' and the 'Measured pitch' values. They must satisfy the following inequality:

$$(\text{Horizontal printing density}) \geq \text{round}[(\text{Sequence length}) \times (\text{Measured pitch})]$$

In this inequality, the 'Sequence length' is the number of images in the sequence. It is not provided explicitly by the user but is determined internally by Grape. Any

job with parameter values that violate this inequality will cause an error. We recommend adjusting the values of the concerned parameters so that

$$(\text{Horizontal printing density}) \sim 2 \cdot \text{round}[(\text{Sequence length}) \times (\text{Measured pitch})]$$

The reason for this is explained in the author's book (Weissman, 2018). Examples of valid and invalid job parameters values are given in Table 2.

Table 2: Examples of valid and invalid job parameters

Parameter	Valid parameters values	Invalid parameters values
Horizontal printing density	720	150
Sequence length	6	6
Measured pitch	60	60

For the sequence length and measured pitch shown in this table, the horizontal printing density must be at least $6 \times 60 / 2 = 180$. Therefore, the first column is valid, and the second is not. A violation of this constraint will terminate Grape.

9.2 Paths

Grape uses three paths: the job path, the sequence path, and the saved interlaced image path. The job and the interlace paths are saved and will be used for the next run, to reduce the navigation effort. For example, if you store all your jobs in a certain folder, Grape will automatically open that folder for you when asking to open a new job file.

The paths file is created after the first run of Grape. It is saved in a text file Grape_paths.txt, in the same folder as Grape. You can erase or edit this file. If you delete this file, the search will start from the Grape folder (as will happen on the first launch).

9.3 Saving the interlaced image

The default extension in the "Save interlaced image" window is 'tif', so typing of the extension is optional. Typing either 'myimage' or 'myimage.tif' will save your image as 'myimage.tif.' Saving in another format is not recommended and may spoil the image.

9.4 Links

Pop3Dart website: www.pop3dart.com

Author's email address: itsikw@pop3dart.com

9.5 Grape icon credits

Artist: Alex T

Webpage: <http://www.iconarchive.com/show/fresh-fruit-icons-by-alex-t/grapes-icon.html>

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10 Bibliography

Weissman, Y. (2018). *Lenticular Imaging*. Pop3DArt.