

It's not alchemy. It's not magic. It's science.

Demystifying frame rate conversion

The video world does not have a consistent set of standard formats. Regional variations, differences in artistic intent, and the continued emergence of new production standards have created an environment populated with multiple standards. Any time there's a difference between the format and frame rate used in content production and the format and frame rate of the viewing device, standards conversion (frame rate conversion) is needed. This includes any international content distribution as well as delivery of movies in formats suitable for home TV, PC and mobile viewing.

In the past, it was easy to be unaware of what happened during the conversion process. Motion compensated frame rate conversion sounds like it might be complicated. However, the best frame rate conversion is based on strong scientific principles, where tried and trusted algorithms continue to be improved upon through technical innovation and rigorous testing. In this White Paper, we'll talk about the science and explain why not all converters are the same.

Motion compensated frame rate conversion

If you've read any of our previous White Papers and journal articles, you'll know that motion compensated conversion will provide the best quality results when frame rate converting. Motion compensated conversion avoids the serious loss in quality due to the introduction of glaring artifacts associated with other conversion methods [1]:

- drop/duplicate: motion irregularities
- linear conversion: blur, ghosting, judder and strobing

The general principle of motion compensated conversion is to calculate the speed and direction of moving elements in the video sequence, so that they can be projected into the correct positions in new video frames at the required frame rate.

Figure 1 shows a simple example of a single object moving with constant speed in one direction, where we need to convert the sequence from 60Hz to 50Hz.

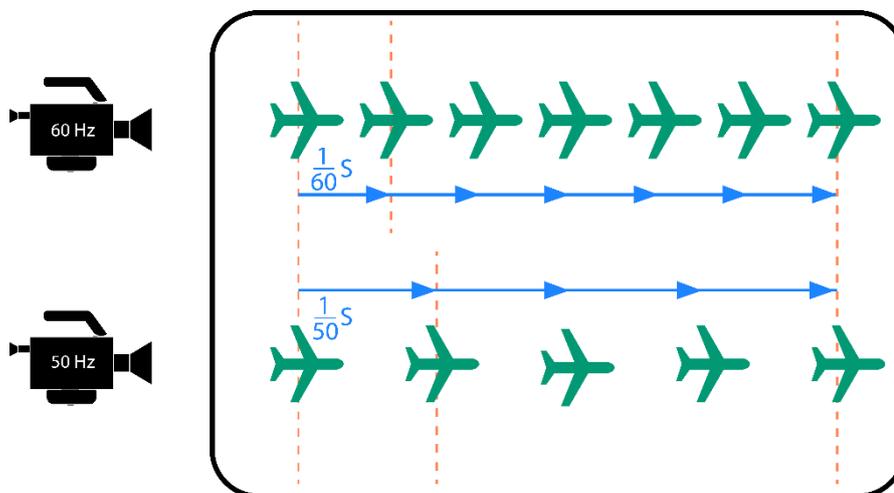


Figure 1: conversion of sequence from 60Hz to 50Hz

To produce a new frame at a new temporal position (where the dashed line is), we calculate the movement of the object from the frame we have available, then work out where it should have reached in the newly created frame, illustrated in Figure 2.

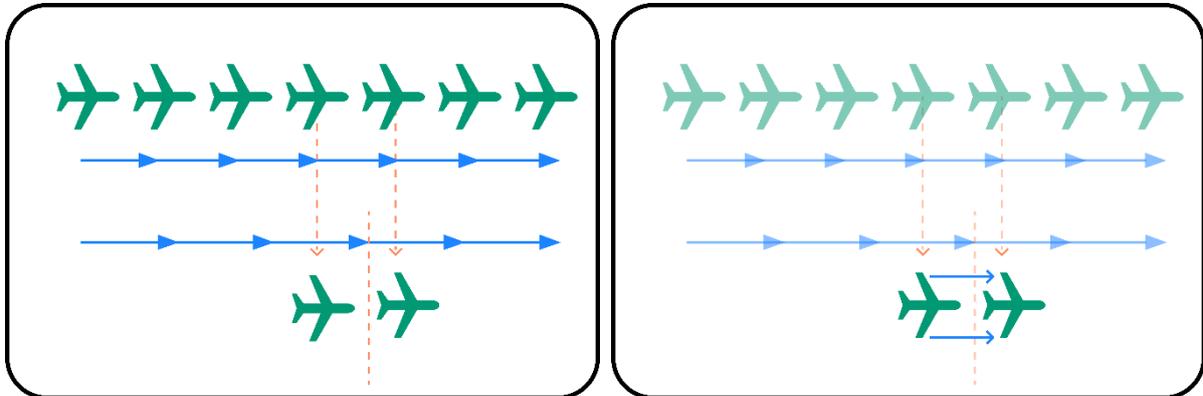


Figure 2: calculating where the object has to move to

As mentioned in some other InSync Technology articles [2], [3], motion compensated conversion has two main steps: estimating the motion ("calculation of motion transforms"), then applying that motion to the objects to create the new frames at the required temporal position ("picture building").

The small print

When video sequences contain clearly defined foreground objects on simple backgrounds, like our aircraft example above, calculation of motion vectors is a relatively tractable process. But real video isn't simple, so what happens when the video clip is noisy, or contains many small objects, each with their own independent motion, or when objects cross each other? Perhaps the objects come into and leave the scene. Objects also rotate, warp, move into and out of the field of view, and scene lighting can change from frame to frame.

In any of these scenarios, a simple translational processing model will not be adequate, so every motion compensated converter has to include additional processing steps to handle real-life content. When choosing a frame rate converter, many of InSync's customers test it with challenging content that covers the full range of possible conditions including

- Noise e.g. electronic, grain, quantisation
- Compression artifacts e.g. macroblocking
- Excessive aperture correction
- Temporal/spatial alias
- Motion blur
- Abrupt lighting changes
- Small objects
- Fast motion
- Motion complexity

- Transparency including dissolves
- Overlays e.g. caption, scoreboard, bugs
- Periodically repeating detail

Where science helps

At InSync Technology, we have implemented an ongoing programme of research which continually refines the quality and resilience of FrameFormer conversion against a comprehensive set of real-world content challenges, such as those listed above. FrameFormer, motion compensated frame rate conversion software from InSync Technology, identifies all types of motion, including zooms, skews and rotations, that enable perfect picture reconstruction, even with fast movement in low lighting conditions.

Figure 3 shows an example of FrameFormer's superior performance in converting sports material, where an industry equivalent has been unable to correctly process the pan across the pitch. Note the ghosting and the uneven pitch line in Figure 3(b) where the converter has confused the grass with the pitch markings.



(a) FrameFormer



(b) Other motion compensated converter

Figure 3: FrameFormer compared to another motion compensated converter

Content with repeating detail such as fences, window blinds and radiator grilles can cause significant problems, for example the converter may confuse the repeated pattern as an object in motion. When moving, the repeating detail creates an ambiguity as to what is the actual motion of the object. Figure 4 shows the problem in two motion compensated converters, where a periodic pattern becomes broken when it is rotated, whereas FrameFormer provides absolute fidelity in reproducing the pattern.

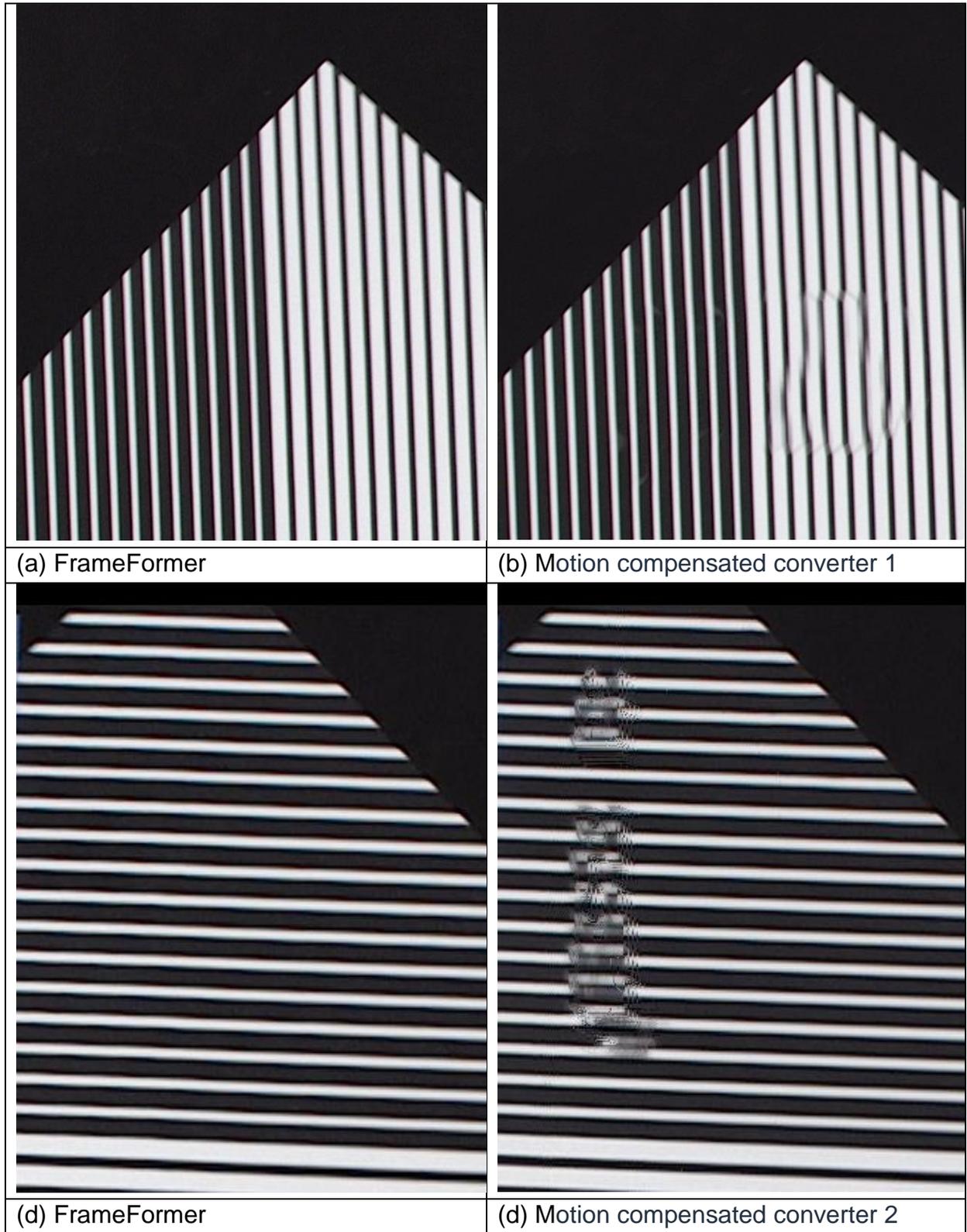


Figure 4: FrameFormer compared to two other motion compensated converters

How to test your converter

We've provided a few examples in this White Paper of the superior performance of FrameFormer motion compensated software frame rate conversion, but we recommend you try it yourself.

A simple way to get started is to try out FrameFormer in [AWS MediaConvert](#). Simply run MediaConvert, and select FrameFormer from the framerate conversion algorithm drop-down menu.

When comparing it to your current converter, we encourage our customers to pick challenging content to fully exercise the processing. Examples of suitable material include:

- Sports
- Action films
- CGI

We recommend avoiding content which rarely creates visible errors, such as:

- Water
- Flames
- Smoke
- Confetti
- Slow motion

When viewing the results of the conversion, we advise watching the output on a monitor which supports your output standard (to avoid double conversion), and which has no special modes turned on which could add artifacts such as "smooth motion" or "frame doubling". Furthermore, we suggest you watch at the correct output frame rate, and beware of frame-stepping as you will not notice motion discontinuities associated with drop-duplicate conversions.

Conclusion

Good quality motion compensated frame rate conversion is achieved by application of precise algorithms which take into account the realities of real-world content. There's no alchemy, no magic, just science.

To find out more about FrameFormer, visit

<https://www.insync.tv/software-solutions/frameformer-saas-2/>

or email enquiries@insync.tv

References

[1] Hobson P, "Format and Standards Conversion", in "National Association of Broadcasters Engineering Handbook", Edition 11, Routledge, 2017. ISBN 9781315680149

[2] "Take control of your content in the Cloud with InSync FrameFormer", <https://www.insync.tv/wp-content/uploads/2021/05/mediablog-take-control-of-your-workflow.pdf> (last accessed Jan 2022)

[3] "Frame rate conversion - the InSync difference", https://www.insync.tv/wp-content/uploads/2019/09/the_InSync_difference.pdf (last accessed Jan 2022)