

Power Signature for Digital Humanities and Immersive Media

Hui Su, Adi Hajj-Ahmad, Chau-Wai Wong, Ravi Garg and Min Wu



What is ENF?

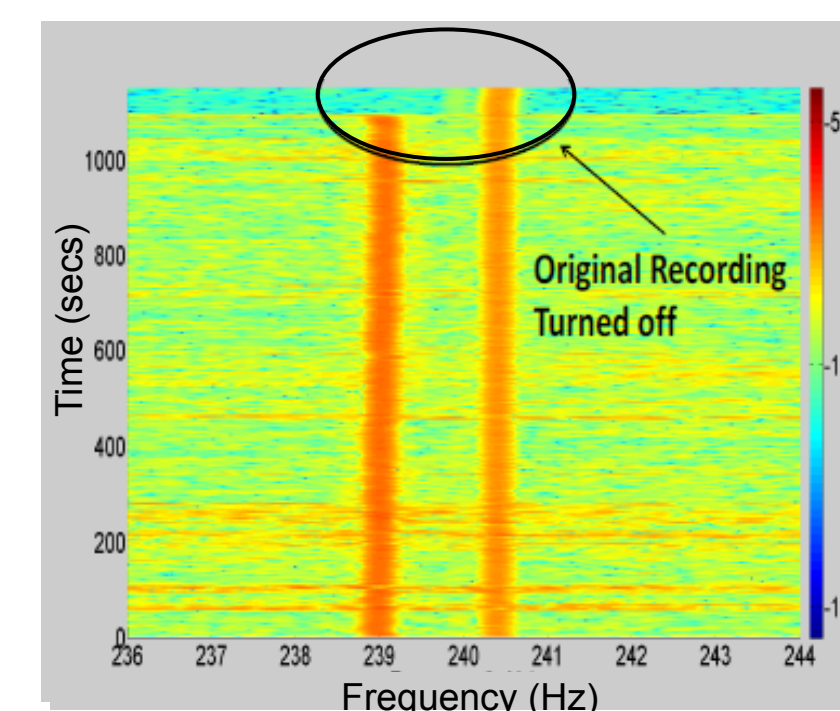
- **Electric Network Frequency** – nominally 60Hz in North America and 50Hz mostly elsewhere.
- ENF can be captured by audio/video recordings, due to electromagnetic influences.
- ENF fluctuates around nominal value due load changes in the grid.
- Changing instantaneous ENF values over time form the **ENF signal**.

ENF for Digital Humanities

Temporal Alignment of Historical Recordings

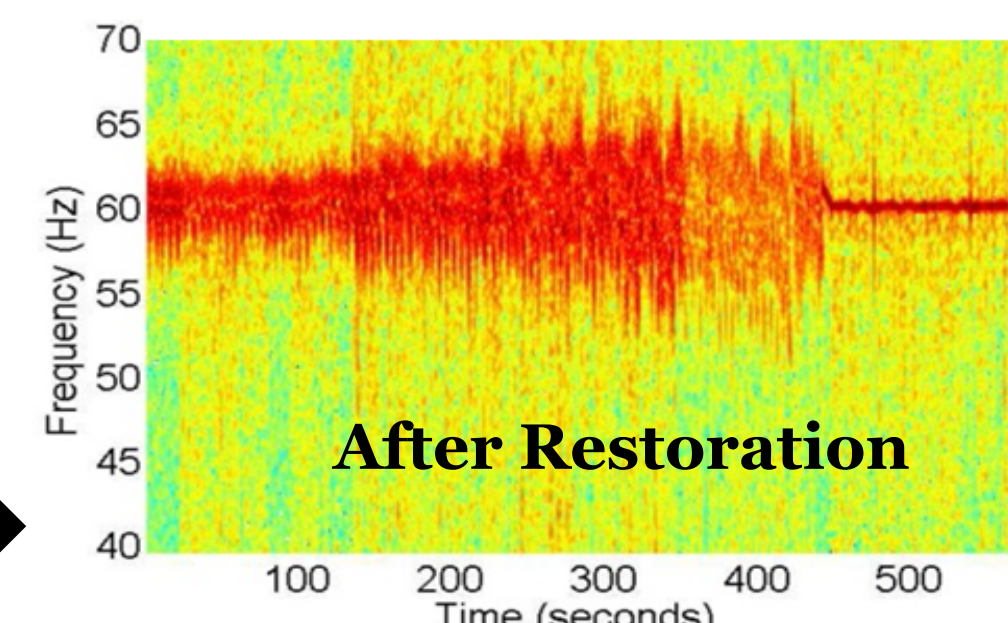
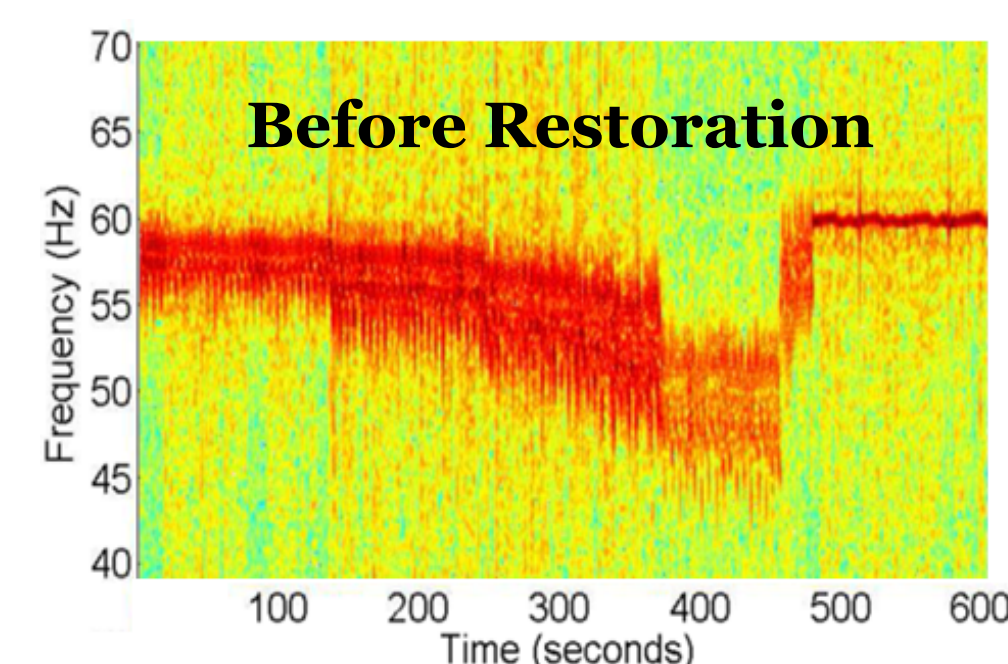
- Two ENFs can appear in digitized historical recordings:
 - ENF from initial recording time and ENF at digitization time.
- Envision to assemble a historical ENF database to help timestamp old recordings of interest.

Digitized Kennedy White House 1962 recording



Speed Restoration of Digitized Audio

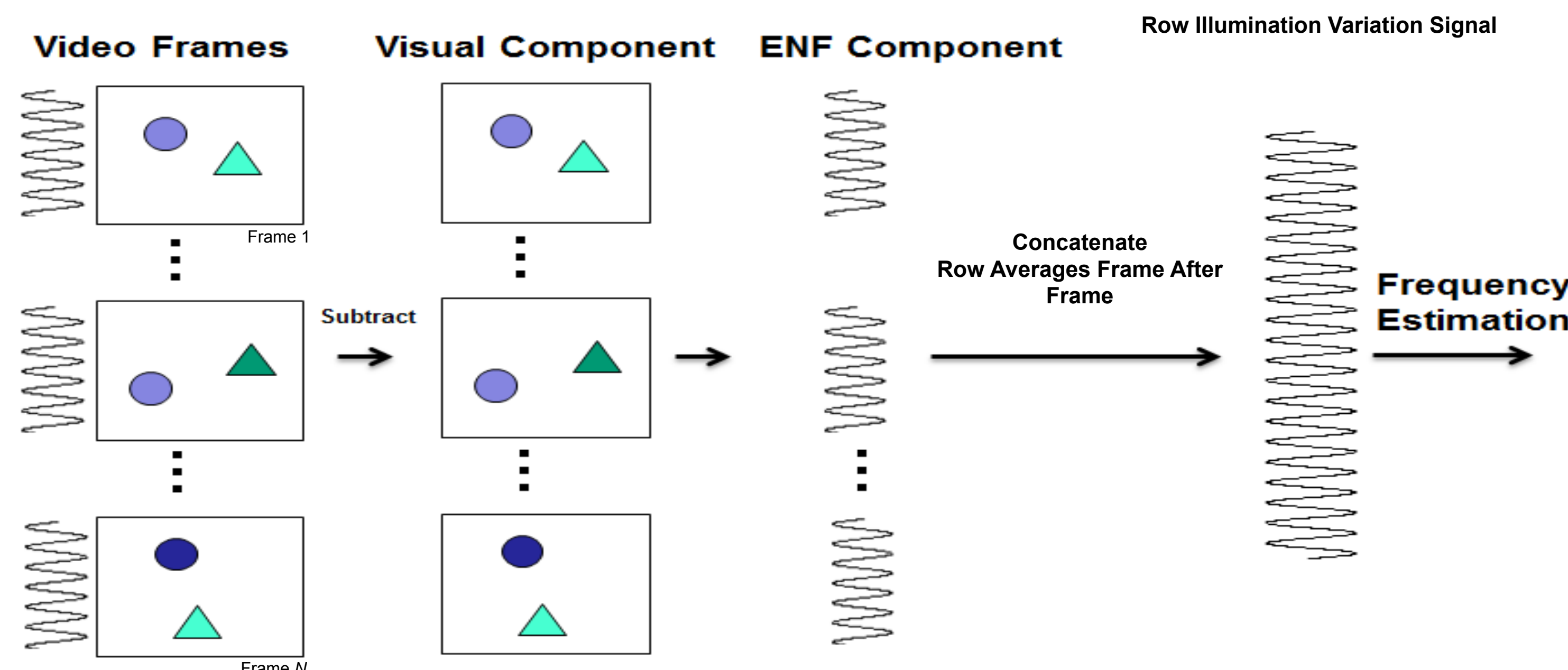
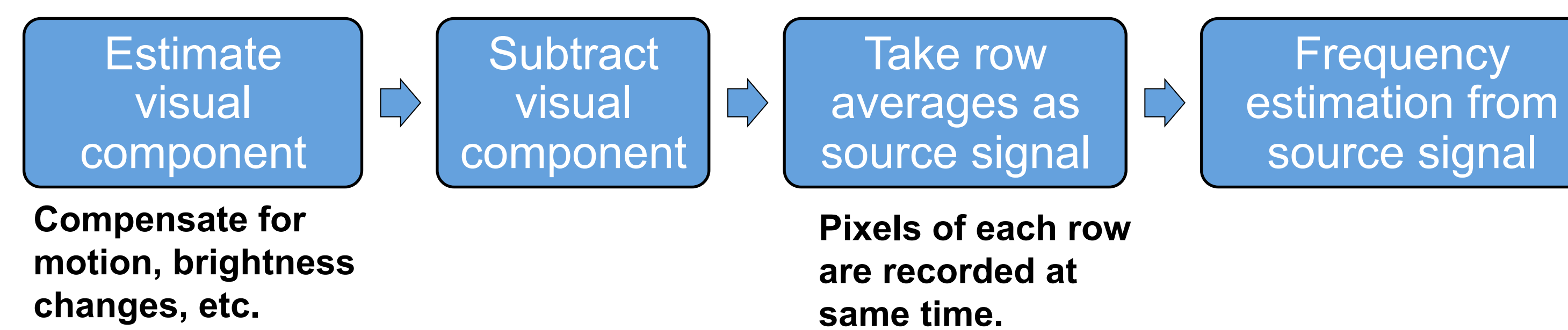
- Speed offset may occur in digitized audio recordings.
 - Due to inconsistency of tape rolling speed in analog devices.
 - Lead to severe perceptual distortions of the audio.
- ENF signal serves as a reference for speed restoration



Digitized Apollo 11 Recording →

ENF for Multimedia Synchronization

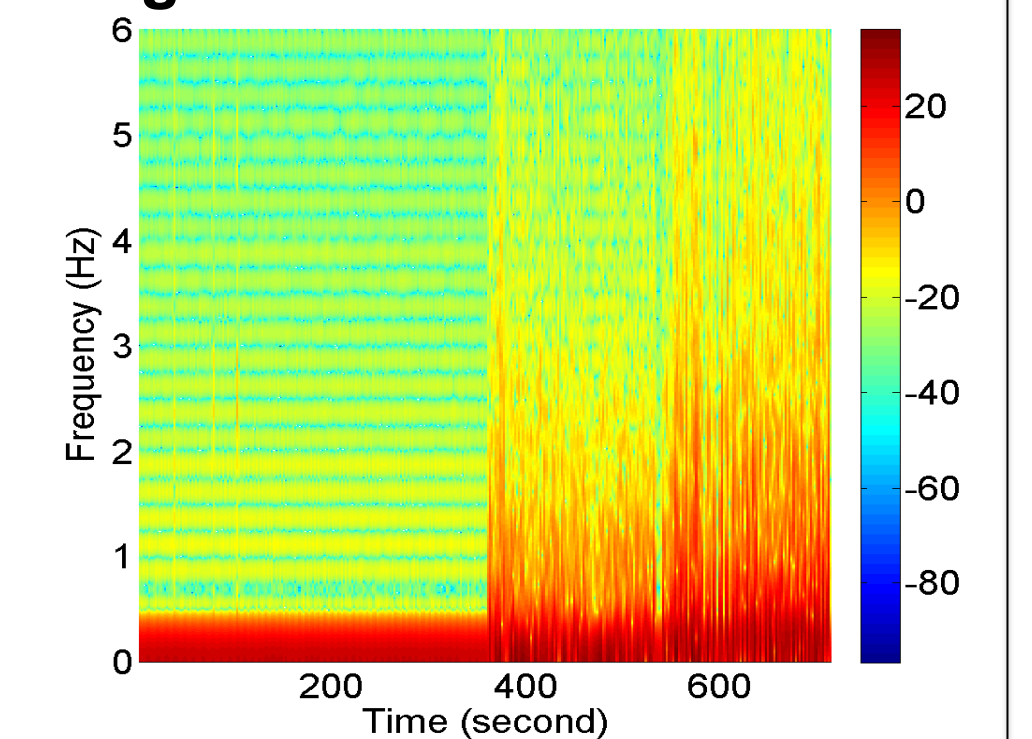
- ENF embedded in video signals is aliased due to low frame rate of cameras (ranges between 24-60fps).
 - Overcome aliasing problem for CMOS imaging sensors by exploiting *rolling shutter*, where lines are read in sequentially as opposed to all at once as with *global shutter*.



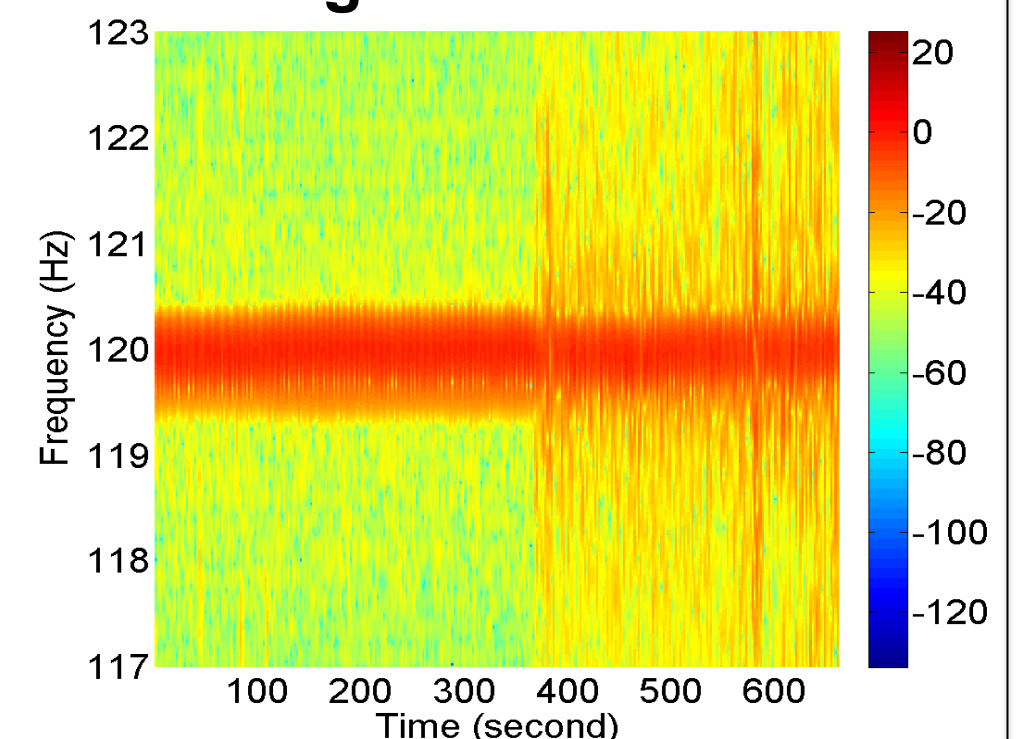
Example of rolling shutter effect from Wikipedia.



Video spectrogram – global shutter



Video spectrogram – rolling shutter



- Conventional media synchronization methods rely on visual cues.
- Use ENF signal to temporally synchronize multiple streams to support immersive multimedia experience.
 - No constraint on viewing angle or camera calibration.
 - No view or content overlap required.
- ENF is extracted from audio or visual tracks and used as a timing fingerprint for temporal alignment.

Frames from two videos synchronized using ENF

