Prototyping Mid-Infrared Detector Data Processing Algorithms

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Infrared Detectors Generate Torrents Of Data

- Megapixel and larger infrared detector arrays in several technologies are available covering the 1 – 30 μm spectral range
- Particularly, in the thermal infrared (> 3 μm), data rates can be quite high due to background emission
- The challenge: in our particular case, each array has
  - 1024x1024 light sensitive pixels divided into 4 outputs
  - “Reference pixels” added to all 4 outputs; mimic "dark" detectors; located on the left and right edges of the image
  - A “reference output” that averages signal from 8 reference pixels; brought out through a 5th output channel
  - A data rate of 1290x1024 pixels in 2.75 seconds – 6.5 GB of lab data in 1 hr, largest to date is 11.8 GB

Data Reordering Requirements

Data is output serially – one frame is a string of 1,320,960 values.

1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Simple reformatting as a 1290x1024 2-D array interleaves reference data with optical data – produces "jail-bar" pattern and degrades compression ratio.

1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Instead, we can strip out the reference data and pack it onto the bottom, producing a 1032x1280 pixel frame.

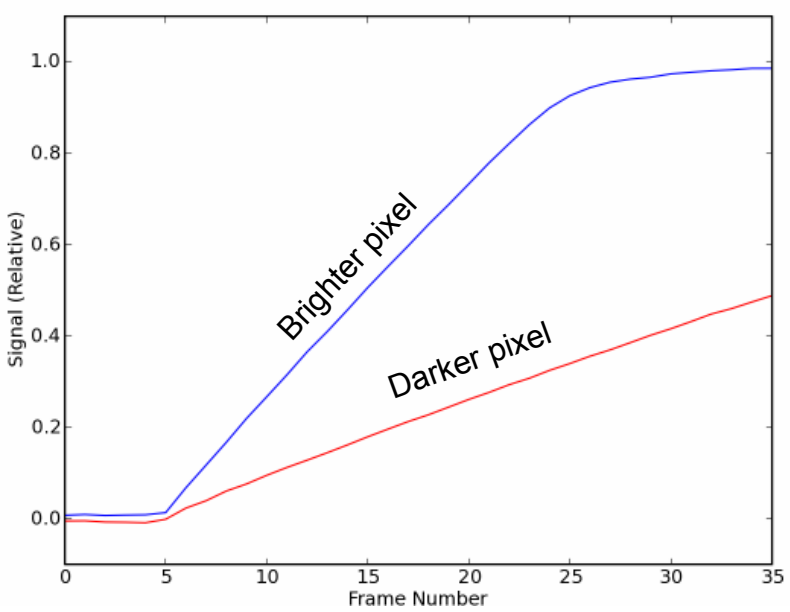
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
1	2	3	4	1	2	3	4	1	2	3	4
5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5

Reordering Code Snippets

```
# Do all the setup stuff, file name checking, options, etc.

# Open a memory map to the data, int32 data type
m=np.memmap(fn,mode='r',dtype='i')

# Grab a frame and reshape it
a=(m[fm_beg:fm_end].copy()).reshape(1024,1290)

# Set up an index to address individual channels
z=np.arange(0,1289,5)+n

# Grab the 5 channels, add offset to index to change
c0=np.take(a,z+0,axis=1) ; … ; c4=np.take(a,z+4,axis=1)

# Reshape each to 3-D to set up interleaving
c1a=c1.reshape(1024,258,1) ; … ; c4a=c4.reshape(1024,258,1)

# A bit of trickery to reinterleave the data
x=np.concatenate((c1a,c2a,c3a,c4a),axis=2).reshape(1024,1032)

# Remember the reference? Reshape to append to the bottom
y=c0.reshape(256,1032)

# Produce the final frame
z=np.concatenate((x,y),axis=0)

# Add it to the output cube and when finished, write to a FITS file
```

Fitting Slopes To All Pixels

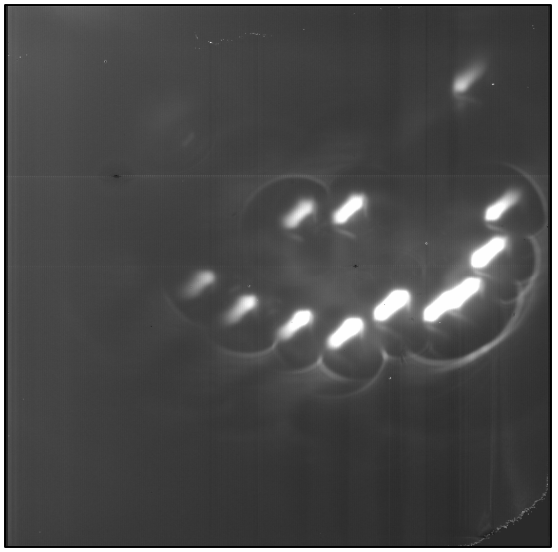
- Pixels integrate signal approximately linearly
- Sample the output of each pixel once per frame time
- Processed signal level (i.e. image) is obtained by fitting a slope to each of the > 1 million pixels




```
# Set up slope factor argument, t = time per frame, n = number of frames
arg=12./t/(n**3-n)

# Create summing array of zeroes
sum=np.zeros((ny,nx),dtype='f')

# Loop through the frames; multiply each frame by weight and then sum
for i in range(n) :
    sum=sum+(i-(n-1.)/2.)*frames[i,:,:].astype('f')

# Multiply by factor and return
return arg*sum
```

The Choice of Python + Numpy

- Needed the ability to explore “how to” process the data, not to just do it
  - C & Fortran – too long a development time
  - IDL – too expensive to run everywhere
- Numpy (and numarray) have a rich set of N-dim features
  - Concatenating, transposing, and reshaping with specific axes can produce complex dataset transforms
  - Trivial extractions allow the examination of individual frames or pixels from data cubes
- All preliminary processing software in python + numpy + matplotlib
  - More rigorous processing algorithms are now in IDL, but are informed by the python code



A weak attempt at a smiley face with an engineering-grade detector