# Machine Learning at JVO: from predicting computer mouse movement under high network latency to compressing astronomical data

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**概要**

The Japanese Virtual Observatory (JVO) ALMA WebQL service has recently been upgraded to version 3. Its users are located all over the world. Whilst the latency of a network connection in Mitaka is sub-1ms, the latency rises to 70ms in Shanghai, around 125ms in Europe and probably well over 250ms in Mexico or Chile. The talk discusses some of the challenges faced when providing a web browser-based real-time FITS data cube preview service over high-latency low-bandwidth network connections. In particular we focus on predicting user mouse movements with a Kalman Filter in order to speculatively deliver the real-time spectrum data corresponding to where the user is likely to be looking at in the near future. The other countermeasure comes with the adoption of the efficient Better Portable Graphics (BPG) image format, which itself is based on the HEVC video compression standard used to compress 4k/8k video streams. Also, in preparation for future terabyte-class FITS files from the ALMA telescope we are experimenting with artificial neural networks for compressing FITS data cubes. The goal is to reduce correlations across the X-Y and frequency/velocity dimensions. Another place where we use artificial intelligence is in deciding, based on the image pixel histogram, which tone mapping function (linear, log, sigmoid etc.) should initially be used for presenting a FITS image in a web browser. Astronomical FITS files have a High Dynamic Range (HDR) which needs to be converted into a 8-bit greyscale. Choosing a reasonable tone mapping function for this conversion is not trivial.

## 1. Mouse movement tracking/prediction with the Kalman Filter

Please refer to 図1.

## 2. Image tone mapping function selection

There are five tone mapping functions to select from: linear, logarithmic, logistic (sigmoid), ratio ($\frac{pixel}{(1+pixel)}$) and square. A simple logistic regression classifier has been employed to decide which function should be used to preview the FITS image in a web browser. User are naturally able to change manually from the settings menu the initial selection made by the computer. Please refer to 図2.

### 3. Image Compression with Radial Basis Functions

In preparation for ALMA publicly releasing several hundred GB large FITS files we are considering various ways of compressing the FITS data. In this example 2D image pixels are represented as a mixture of elliptical Radial Basis Functions:

$$pixel\,(x,y) = bias + \sum_{i}^{N} w_i \exp\left[-\left(a_i\left(x-x_0^i\right)^2 + 2b_i\left(x-x_0^i\right)\left(y-y_0^i\right) + c_i\left(y-y_0^i\right)^2\right)\right]$$

where $bias$, $w_i$, $a_i$, $b_i$, $c_i$, $x^i_0$, $y^i_0$ are free parameters to be learnt during a training phase and $N$ is the number of basis functions, set to be much smaller than the number of pixels in the original 2D image.

図3 shows an example of image compression (reconstruction) with Radial Basis Functions. The original FITS image consists of 1024 x 1024 float32 pixels. It has been reconstructed with 64 x 64 ellipses, achieving a large compression ratio. The image has been compressed down to about 2.3% of the original size.

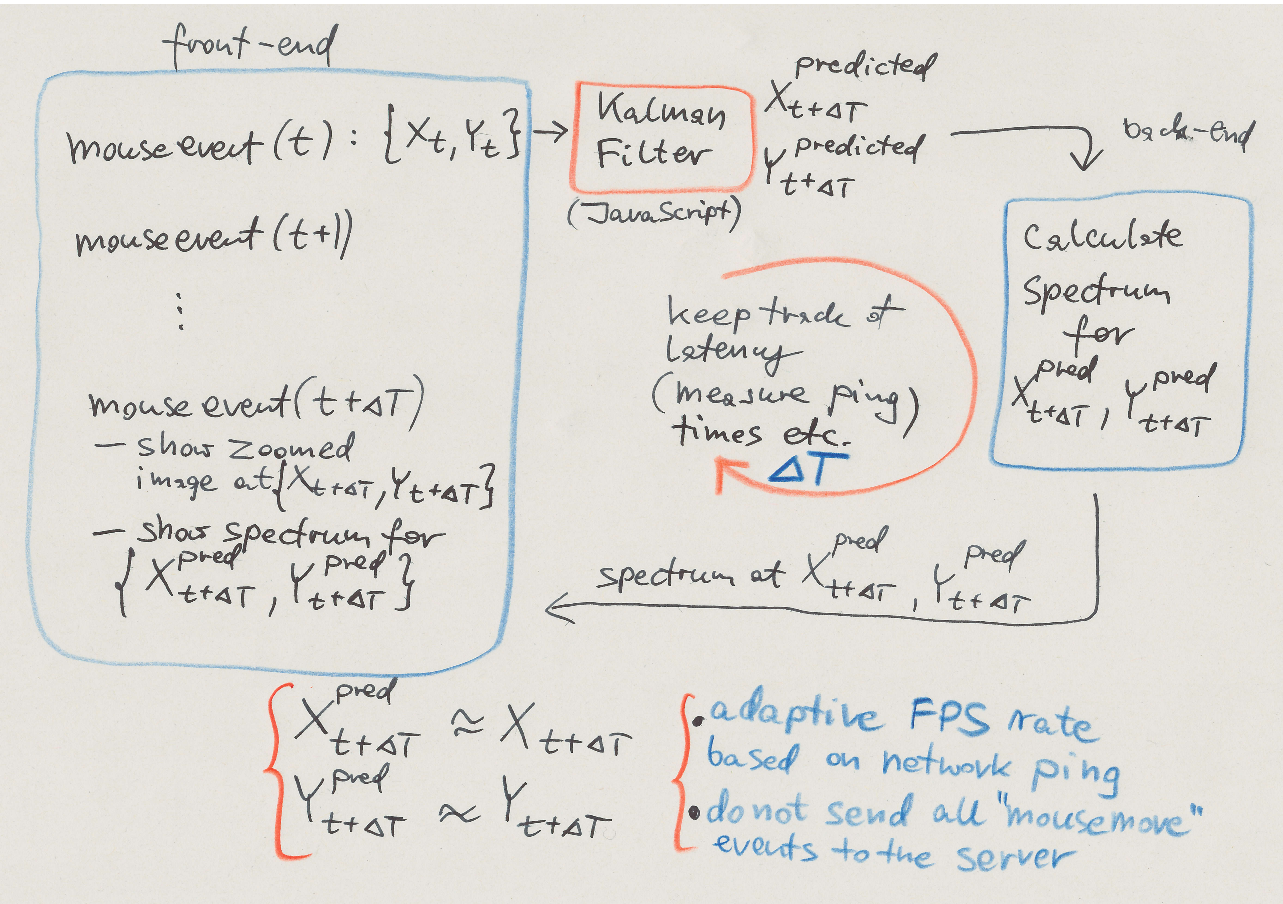


*図 1: Kalman Filter.*

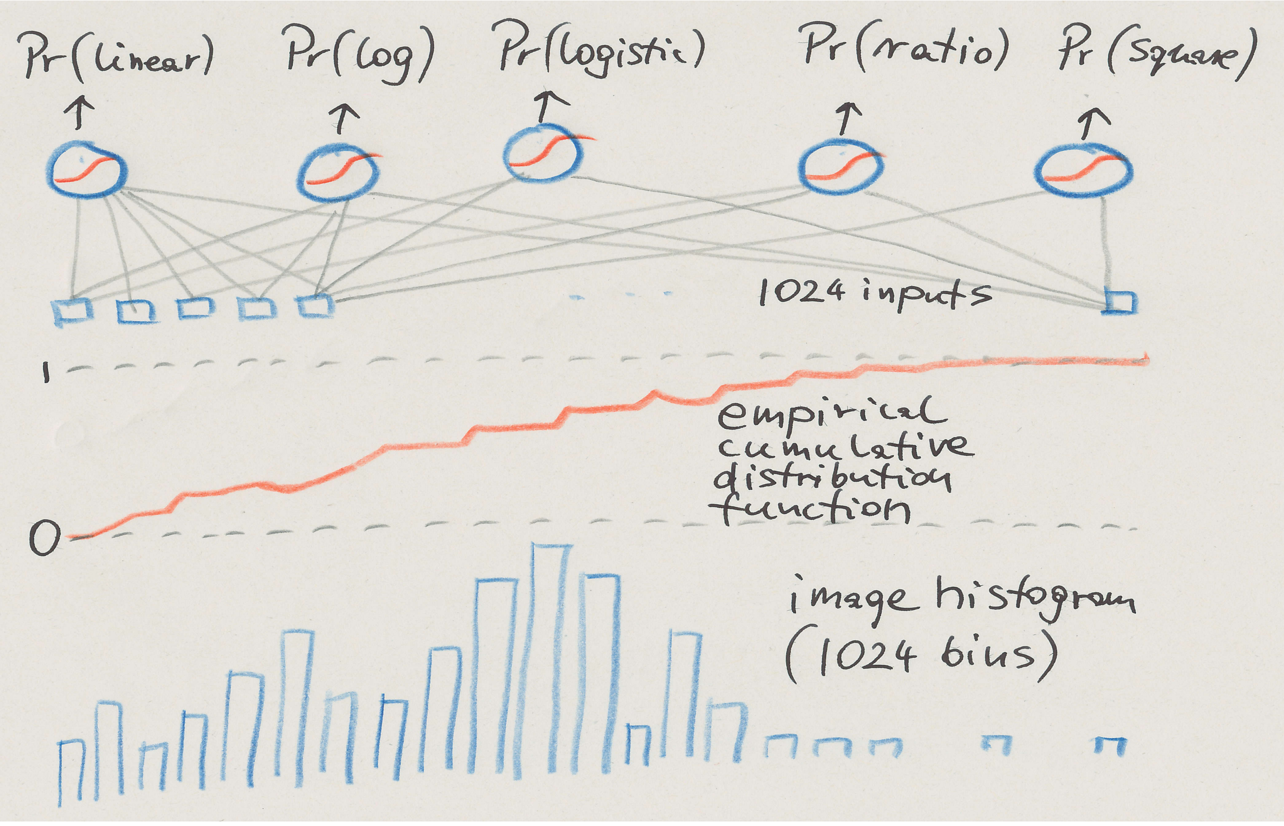


図 2: Tone mapping function selection with logistic regression.

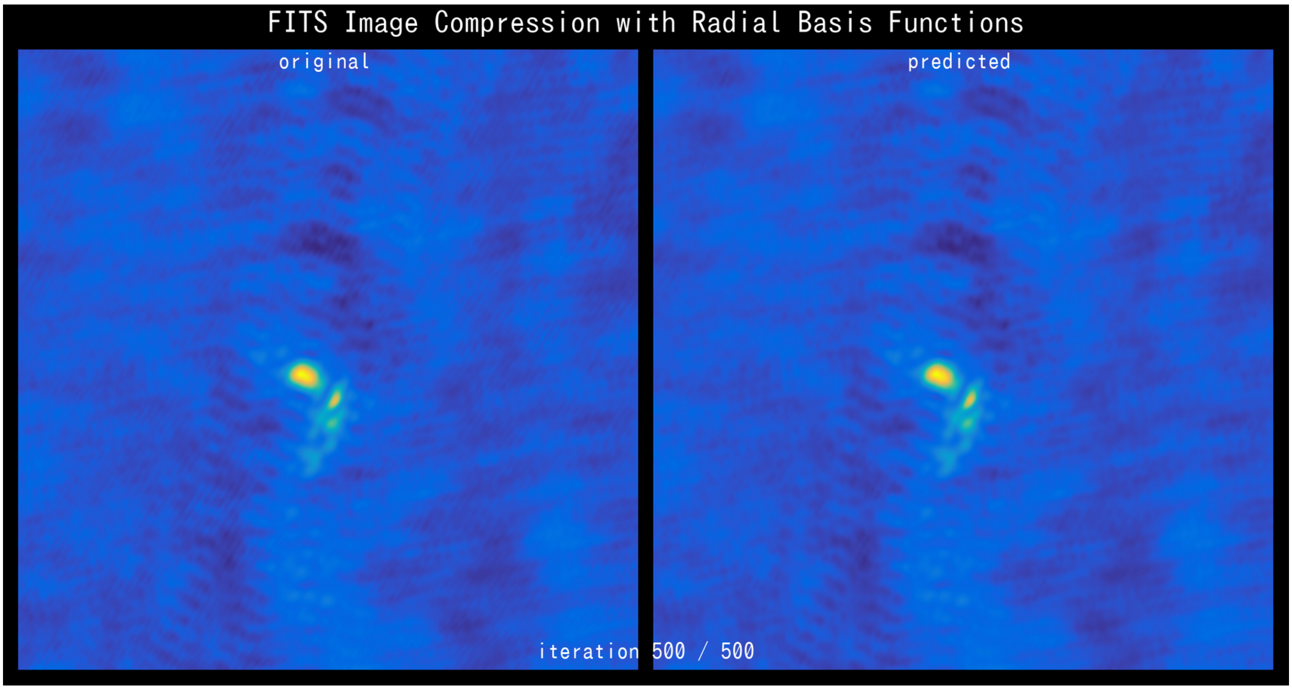


図 3: Image compression: the original image is shown on the left, the image reconstructed with Radial Basis Functions is shown on the right-hand side. Increasing the number of elliptical basis functions will result in more accurate reconstruction at the cost of worsened compression ratio. One needs to strike a balance between preserving small details and reducing the image size as much as possible.