Network State Estimation by Analyzing Raw Video Data

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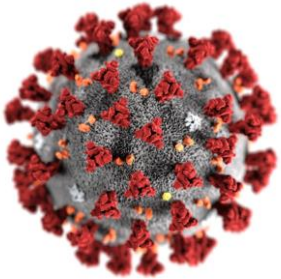
Affiliation: Okinawa National Institute of Technology
Presenter: Ryuma Kinjo

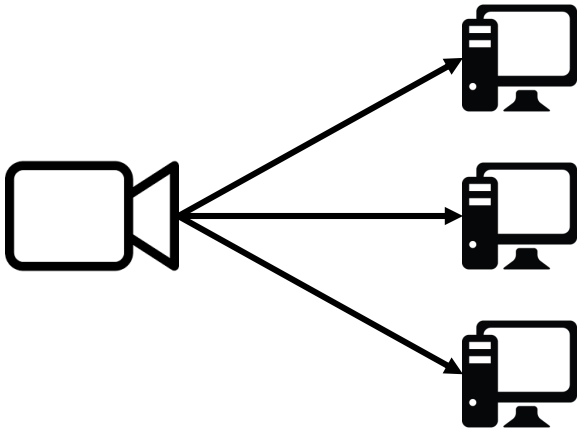
Introduction

YouTube

Netflix



Network Congestion



Optimize Video Quality

How to obtaion network status by analyzing raw video data ?

YouTube Help

Describe your issue

Coronavirus disease 2019 (COVID-19) updates

Current as of 17:30 UTC 17 NOVEMBER 2020

The impact of coronavirus (COVID-19) is evolving every day. Please check back here for regular updates on how YouTube is addressing the situation.

Latest Updates

- **[17:30 UTC 17 November 2020] Update to COVID-19 information panels:** As a continuation of our efforts to combat COVID-19 related misinformation, we're updating our COVID-19 information panels to include links to COVID-19 vaccine info. The update… 19 or COVID-19 vaccine info. The u… COVID-19 vaccine info and are not…
- **[20:… …20] Prem…** …ited to…
- …epr… …ation…
- **[16:30 UTC 13 July 2020] New hea…** not only affects physical health, it … information more easily, we're intro… assessments in YouTube Search. The panels and self-assessments are currently available in the U.S. and we hope to make the panels available in more countries/regions soon.
- **[23:15 UTC 11 June 2020] Update to the COVID-19 health panel self-assessment:** The self-assessment in the COVID-19 health panel now links to Google's self-assessment screener, which is based on CDC guidelines. The self-assessment screener gives users more info on what kind of support or medical care might be appropriate for them.
- **[17:38 UTC 20 MAY 2020] COVID-19 Misinformation policy:** YouTube has updated its Community Guidelines to include a page on COVID-19 misinformation, which can be found here.
- **[23:34 UTC 30 April 2020] COVID-19 health panel self-assessment:** To help people make decisions about seeking appropriate medical care, we've launched a link to a COVID-19 self-assessment in our COVID-19 health…

Help

- Coronavirus disease 2019 (COVID-19) updates
- Monetization update on COVID-19 content
- YouTube's Community Guidelines
- YouTube policies
- Reporting and enforcement

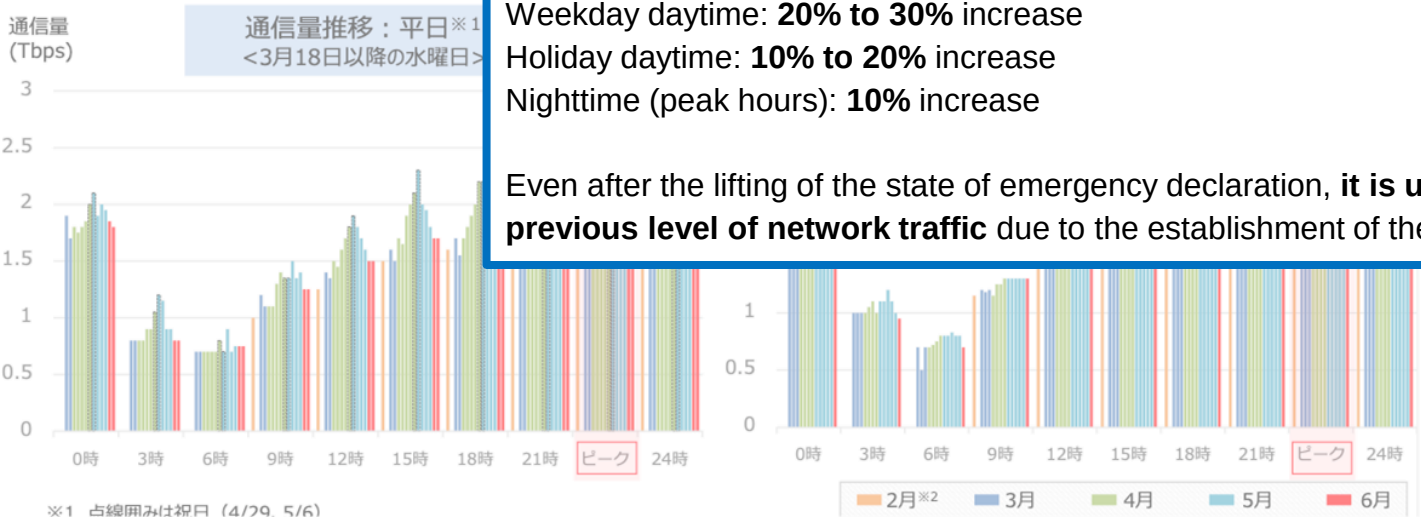
[13:30 UTC 24 March 2020] Update on adjusted bandwidth usage:

Last week, **we temporary defaulted all videos on YouTube to standard definition** in the European Union (EU), United Kingdom (UK), and Switzerland (CH).
Given the global nature of this crisis, **we are expanding that change globally starting today**.

This update is slowly rolling out, and users can manually adjust the video quality.

本年３月以降の我が国におけるインターネット通信量の推移

- テレワークや学習・余暇のための通信の利用増により、 昼間の時間帯の通信量は大きく増加
  直近のデータでは
  2月下旬と比べ { 平日昼間 ： ２割～３割程度増加 / 休日昼間 ： １割～２割程度増加 } 、夜間（ピーク時間帯）：1割程度増加
- 緊急事態宣言の解除以降、特に平日昼間の通信量は目に見えて減少しているが、新たな生活様式の定着により、以前の水準ま



Compared to late February, the network traffic
Weekday daytime: **20% to 30%** increase
Holiday daytime: **10% to 20%** increase
Nighttime (peak hours): **10%** increase

Even after the lifting of the state of emergency declaration, **it is unlikely to return to the previous level of network traffic** due to the establishment of the new lifestyle.

Introduction

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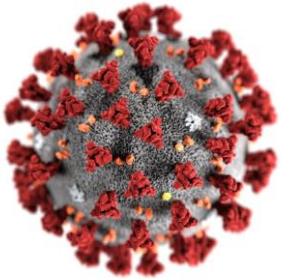
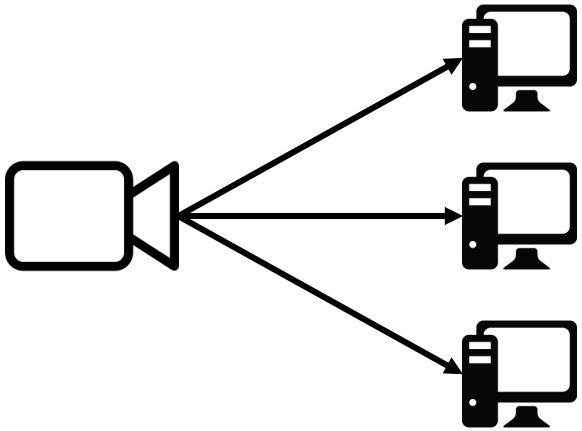


Network Congestion



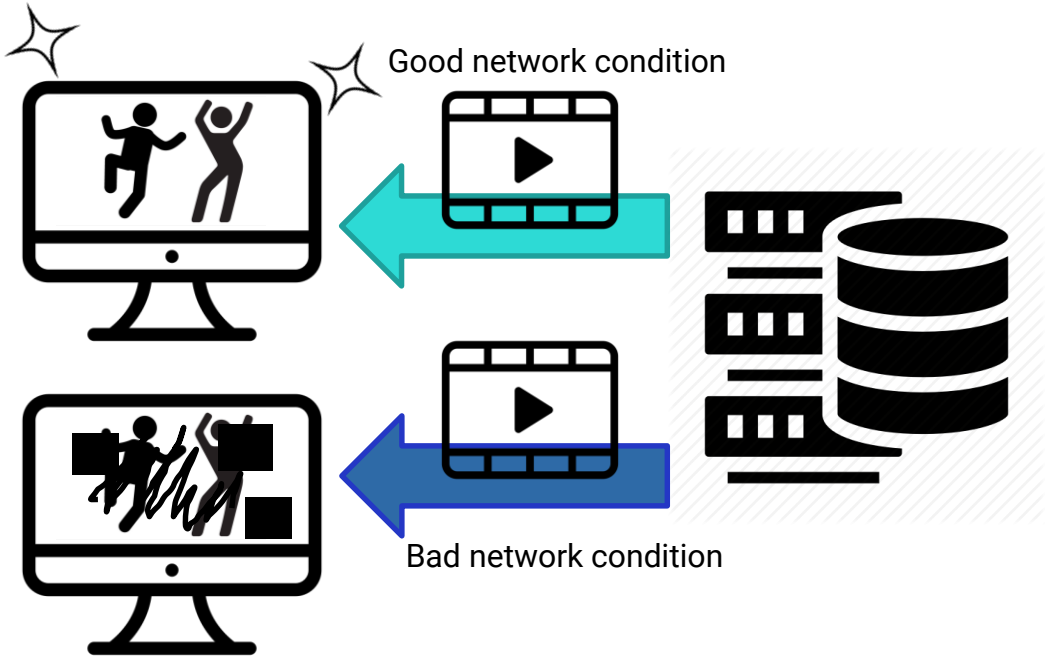
Optimize Video Quality

How to obtaion network status by analyzing raw video data ?

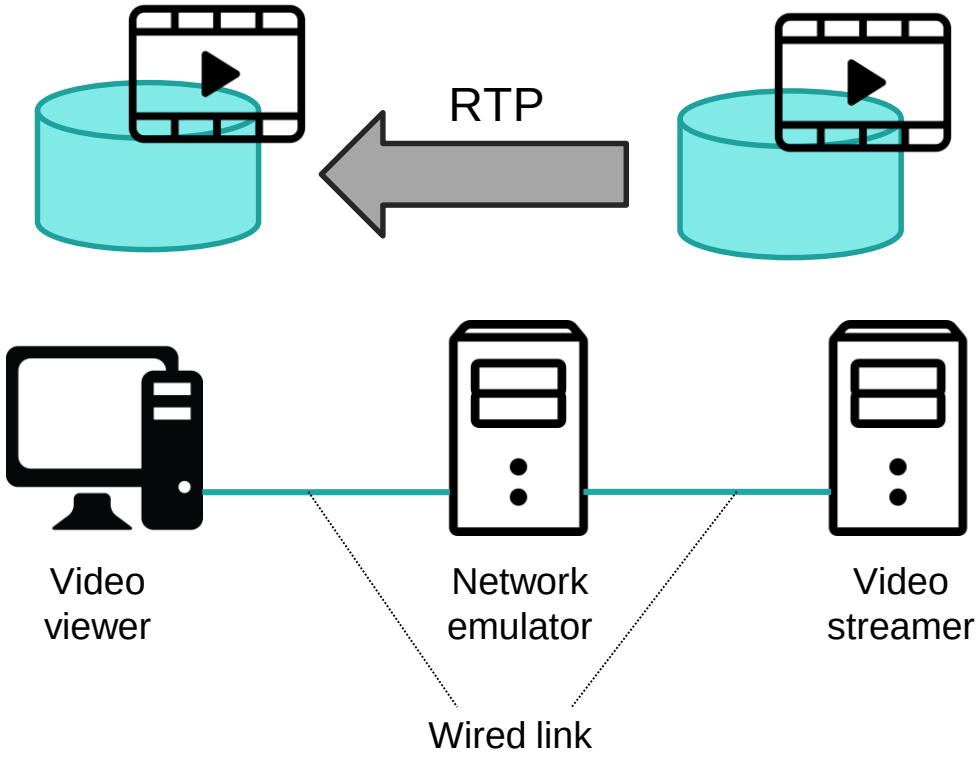
Problem description

High throughput environment
Low packet loss environment

Low throughput environment
High packet loss environment



Problem description



Pattern No.	Throughput	Packet loss
1	10Mbps	0.1%
2	5Mbps	0.2%
3	2Mbps	0.5%
4	1Mbps	1%
5	800kbps	2%
6	600kbps	3%
7	500kbps	5%
8	400kbps	10%
9	300kbps	10%
10	200kbps	10%

YouTube-8M


Chocolate
Cooking


© EM-Rallymedia

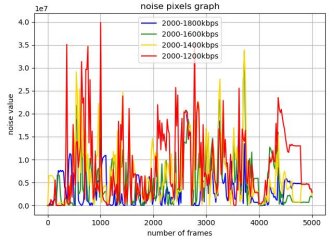

TENGBAT TV


Un video más de RecetasNuestras.com

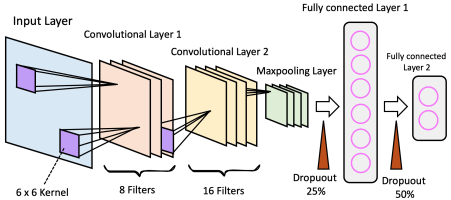

#CursoDecoracion
-MiCasaRevista

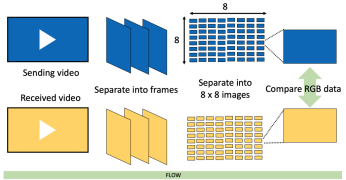
Exist solution

01 Analyzing RGB data

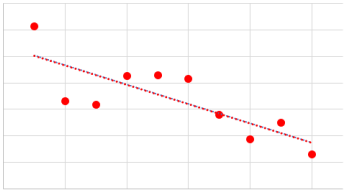


03 Using neural network



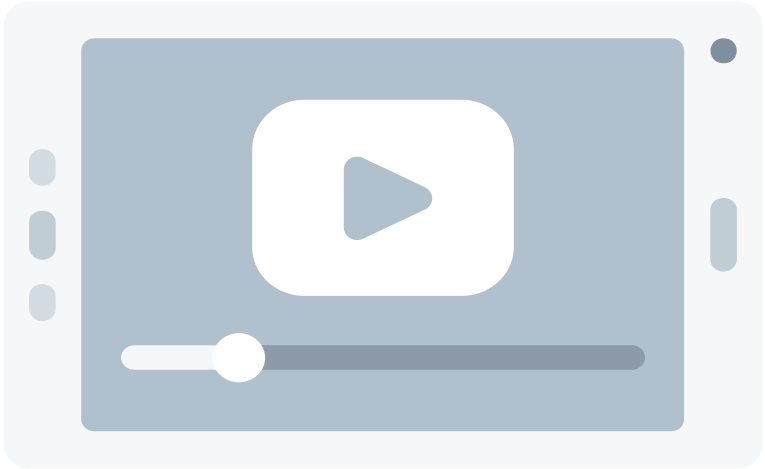


02 Making dataset



04 Estimating network status

01 Analyzing RGB data



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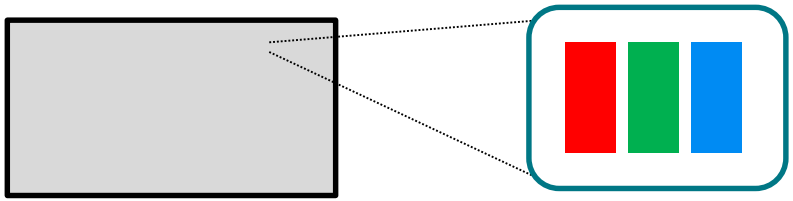
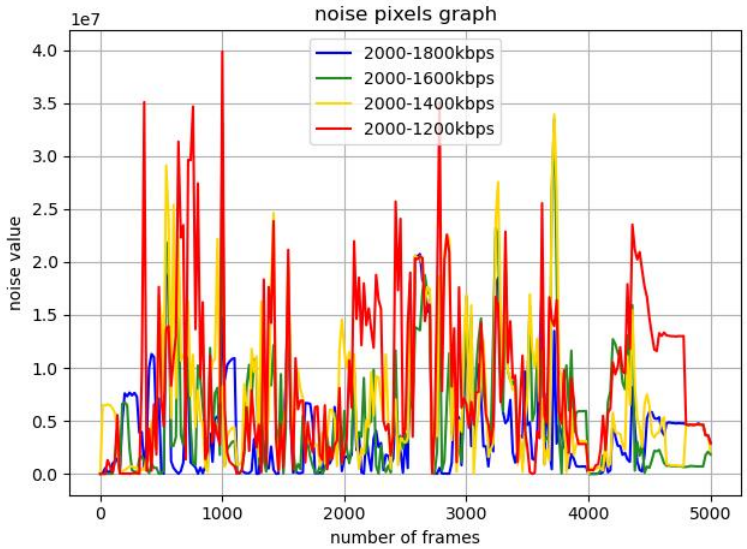




Sending video – 2000kbps video = A_{20}

Sending video – 1800kbps video = A_{18}

Sending video – 1600kbps video = A_{16}

Sending video – 1400kbps video = A_{14}

Sending video – 1200kbps video = A_{12}

$A_{20} - A_{18}$ = Blue line ⟸ Not so noisy

$A_{20} - A_{16}$ = Green line

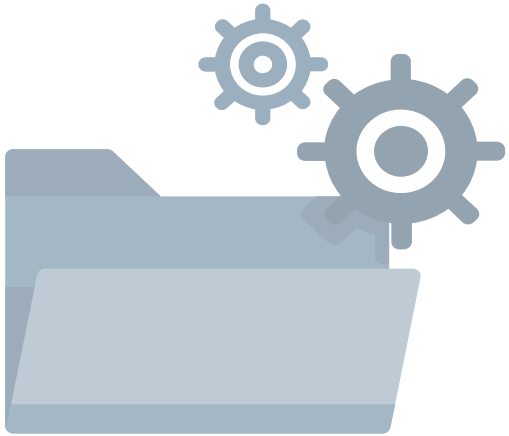
$A_{20} - A_{14}$ = Yellow line

$A_{20} - A_{12}$ = Red line ⟸ Really noisy

Throughput [kbps]	1800	1600	1400	1200
Noise value [$\times 10^9$]	1.0	1.3	1.7	2.2

× 2.2

02 Making dataset



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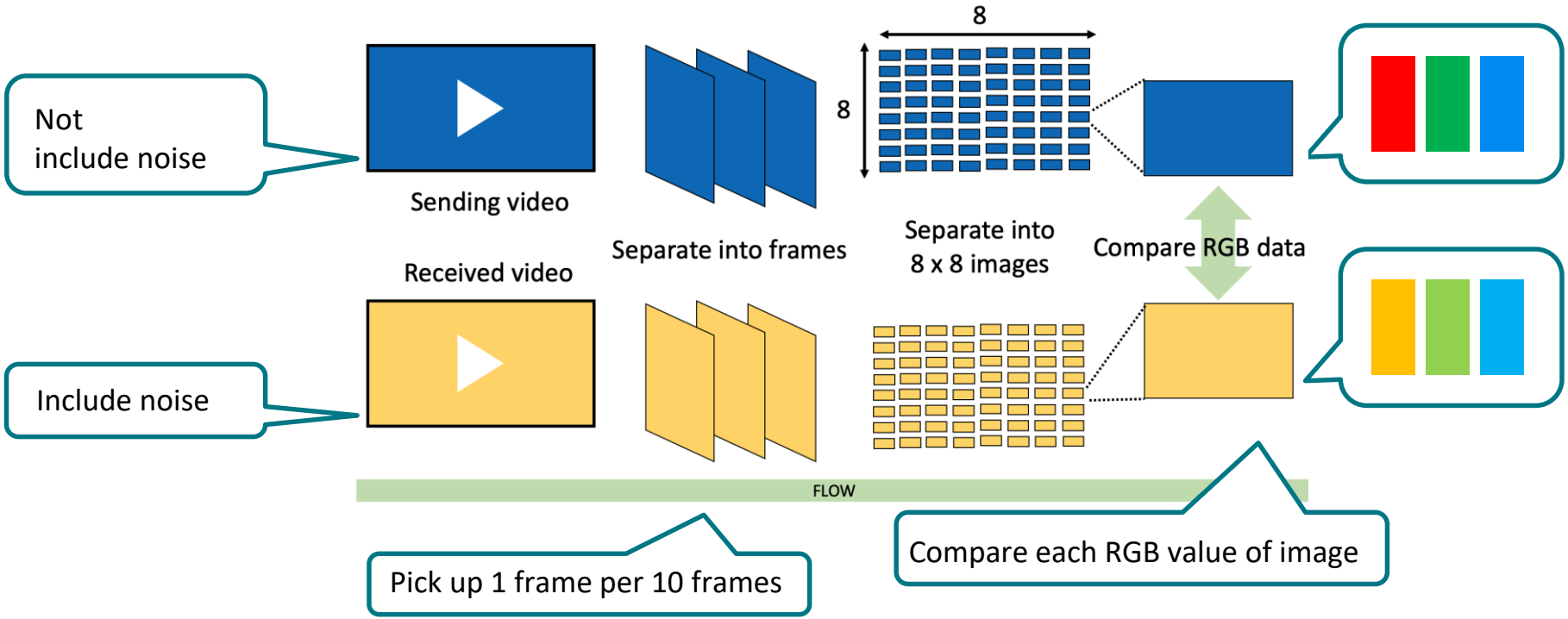

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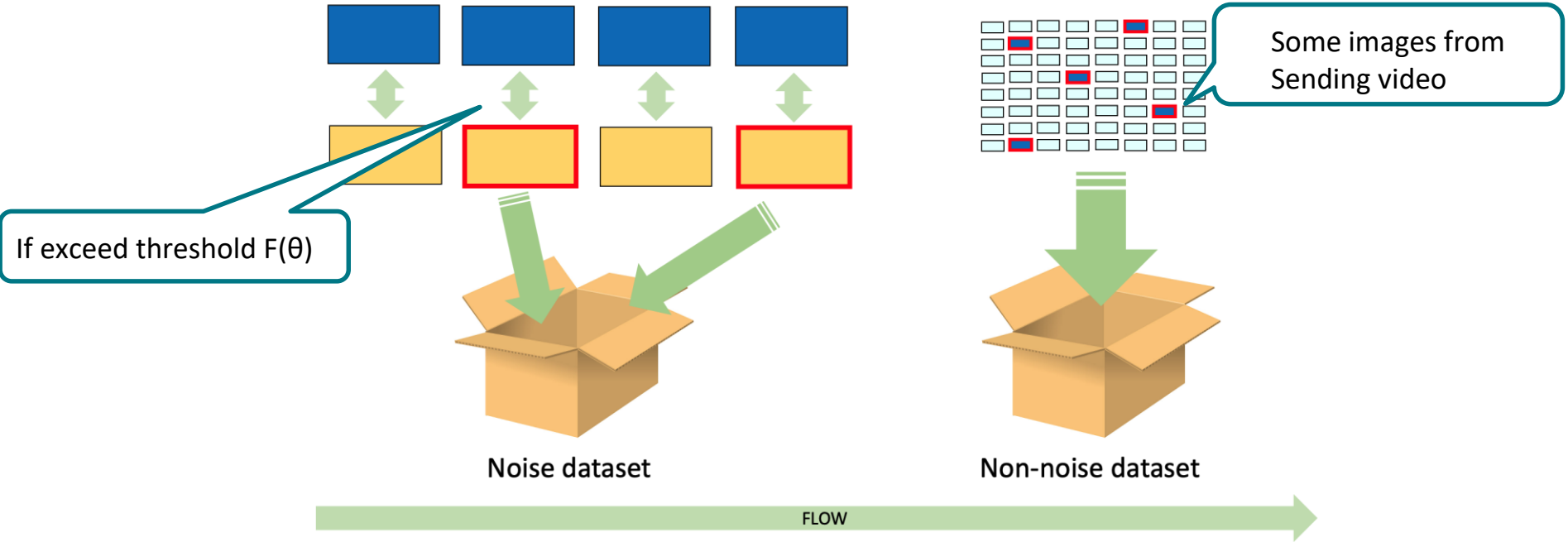

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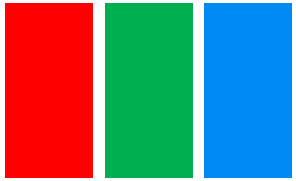
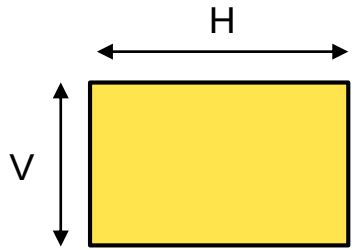


Each color has **0 ~ 255** value range



Total pixel number is **H × V**

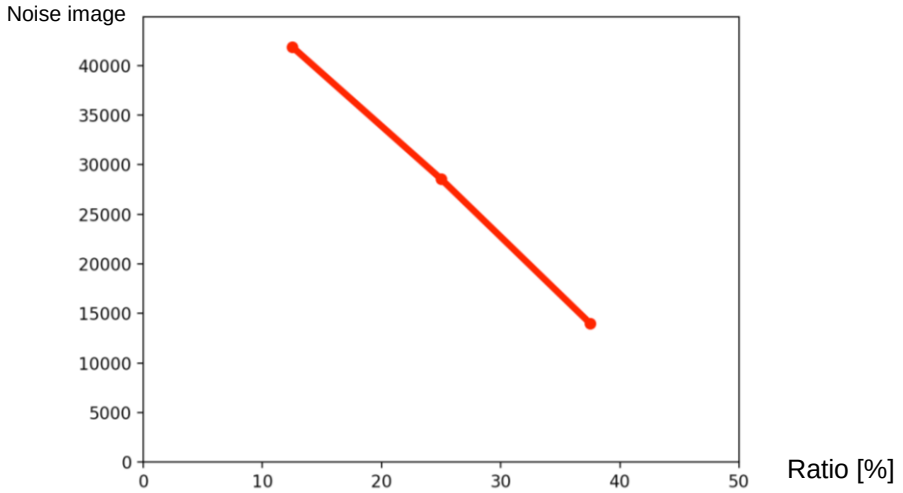
Θ

Value match ratio

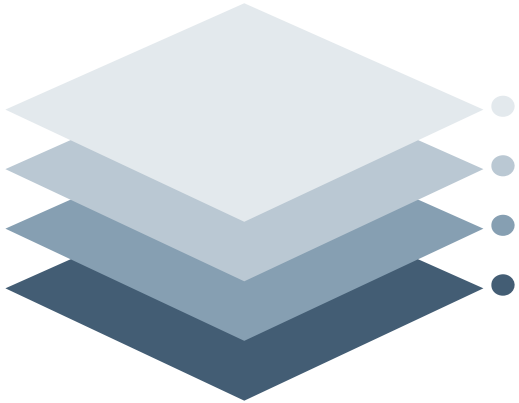
$$Y = 255 \times H \times V \times \theta$$

$$Threshold\ F(\theta) = R > Y\ AND\ G > Y\ AND\ B > Y$$

Relation between ‘value match ratio’ and ‘number of noise image’



03 Using neural network



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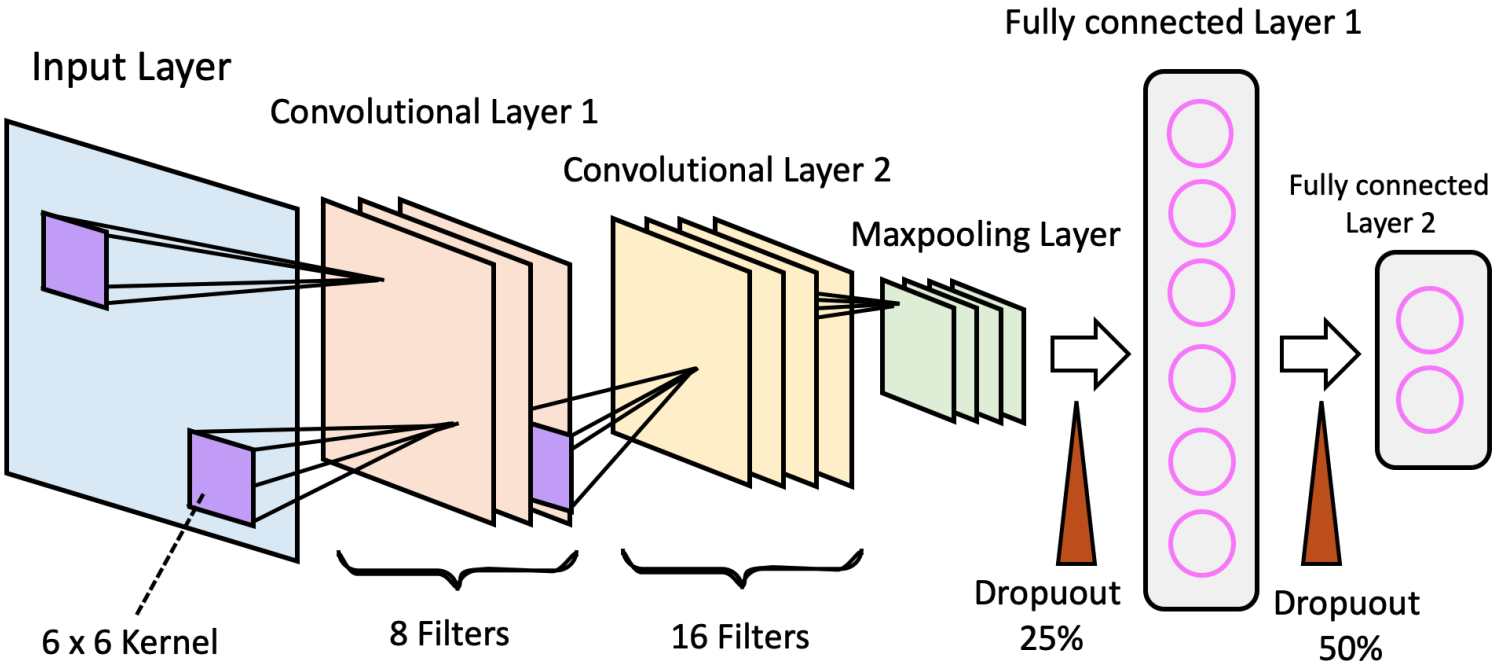

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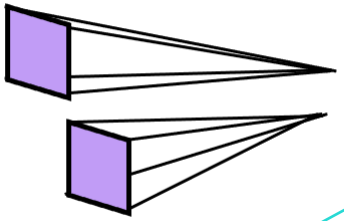
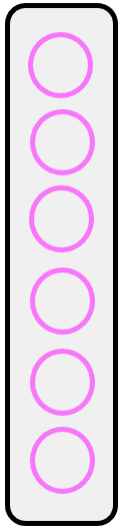


Number of neurons

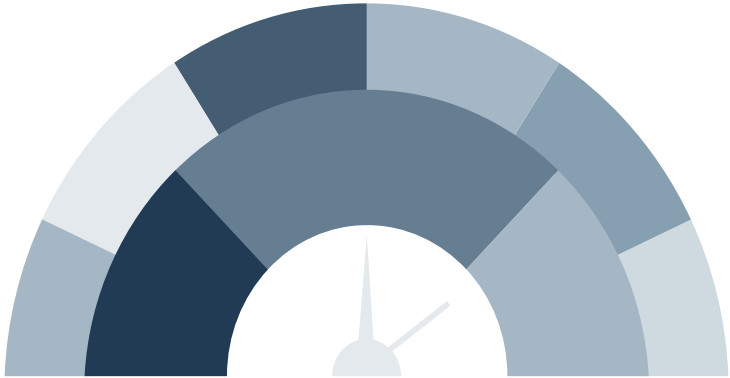
Kernel size

	32	64	128
4 x 4	74%	71%	70%
5 x 5	75%	73%	73%
6 x 6	77%	76%	75%



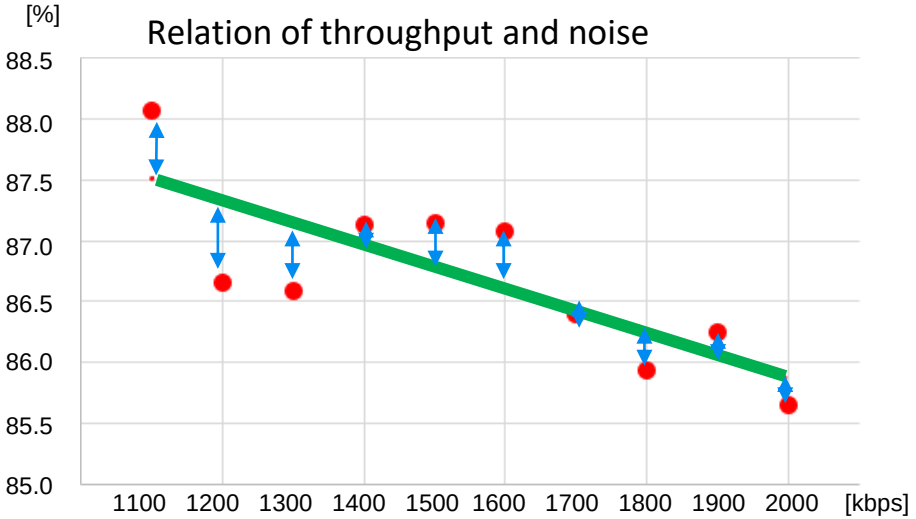
Accuracy of our CNN

04 Estimating network status



04 Estimating network status

[kbps]	Plot values	Linear values
1100	88.0678	87.5814
1200	86.6584	87.4014
1300	86.5873	87.2214
1400	87.1353	87.0414
1500	87.1458	86.8614
1600	87.0806	86.6814
1700	86.3965	86.5014
1800	85.9365	86.3214
1900	86.2509	86.1414
2000	85.6589	85.9614



Red points ... Throughput estimated by CNN
Green line … Optimum linear function

Calcurate differences between Red points and Green line

04 Estimating network status

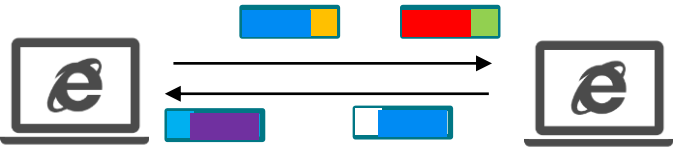
$$MAE = \frac{1}{n}\sum_{i=1}^{n}|Estimation[i] - Answer|$$

MAE = 196.8 [kbps]

The MAE was 196.8. This means that when estimating the throughput, there will be an average difference of 196.8kbps from the actual throughput.

05 We tried to estimate packet-loss rate

We basically succeeded to estimate throughput. But we can't estimate packet-loss rate yet. Our team tried to estimate it using PSNR.



05 We tried to estimate packet-loss rate

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$
$$= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

~30 ⟺ 40~

Noisy image — Clear image

```
28.626441325780164
5500
47.676692281710885
6000
6.790633010662797
6500
47.98582640310569
[361.2019991   20.71854741  19.26520954  17.62536468  18.21581237
  15.20841238  19.69702027  17.68841393  44.39178751  24.82819143
  28.62644133  47.67669228   6.79063301  47.9858264 ]
~/Desktop/Competitions/ITU/codes/PSNR/Compare  master  b
```

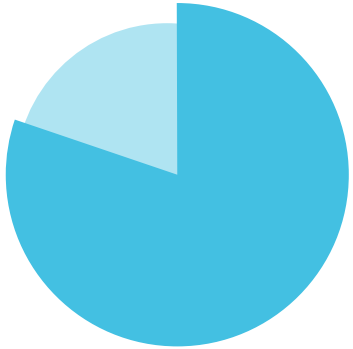
Our team’s initiative achievement rates

60%

Making Dataset

We will try to improve dataset quality and pick up more image feature of RGB data.

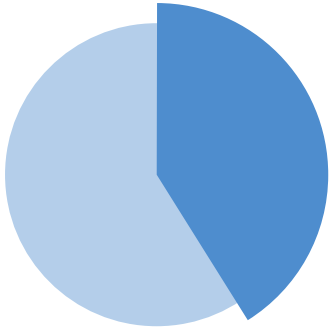
80%



Using Neural Network

Basically we succeeded to make CNN. We will try to combine another NN.

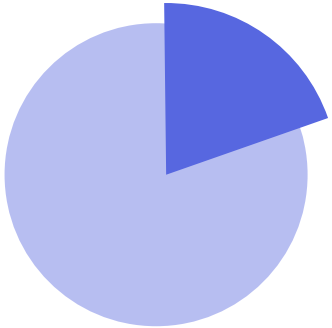
40%



Method of Estimate Throughput

We estimated throupht using optimum linear function but it’s so basic method. We want to estimate it using NN.

20%

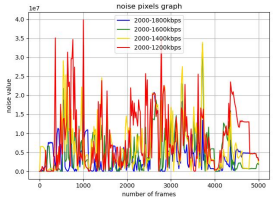


Estimating Packet-loss rate

We just run the PSNR code. We can’t still achieve to estimate packet-loss rate of video.

Unique aspects of our team's initiative

01 Analyzing RGB data



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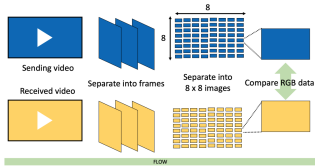

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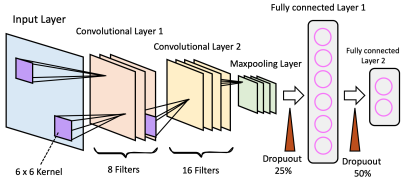
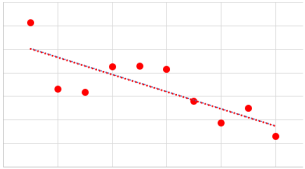
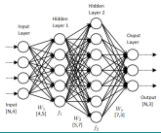


04 Estimating network status



We made dataset based on **RGB data.**

We created **our CNN**.
Revised CNN code so that improve estimation accuracy.



We estimated throughput using **Excel** (Windows app).
We're not use any complicated method. Just use Excel.

Q&A ~Using PSNR and SSIM~

PSNR

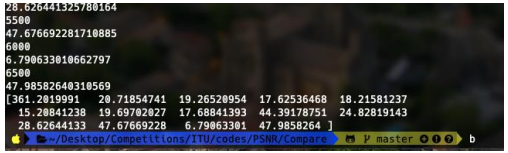
$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$
$$= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

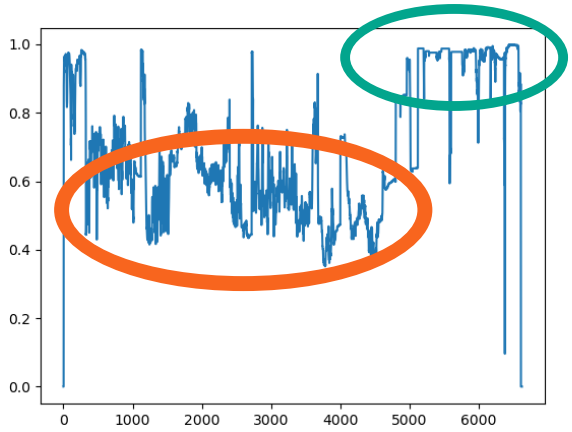
~30 ⟺ **40~**

Noisy image — **Clear image**



SSIM

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_1^2 + \mu_2^2 + c_1)(\sigma_1^2 + \sigma_2^2 + c_2)}$$



Thank you for listening