2021 동계 현장실습
개발 보고서

최우석

목차

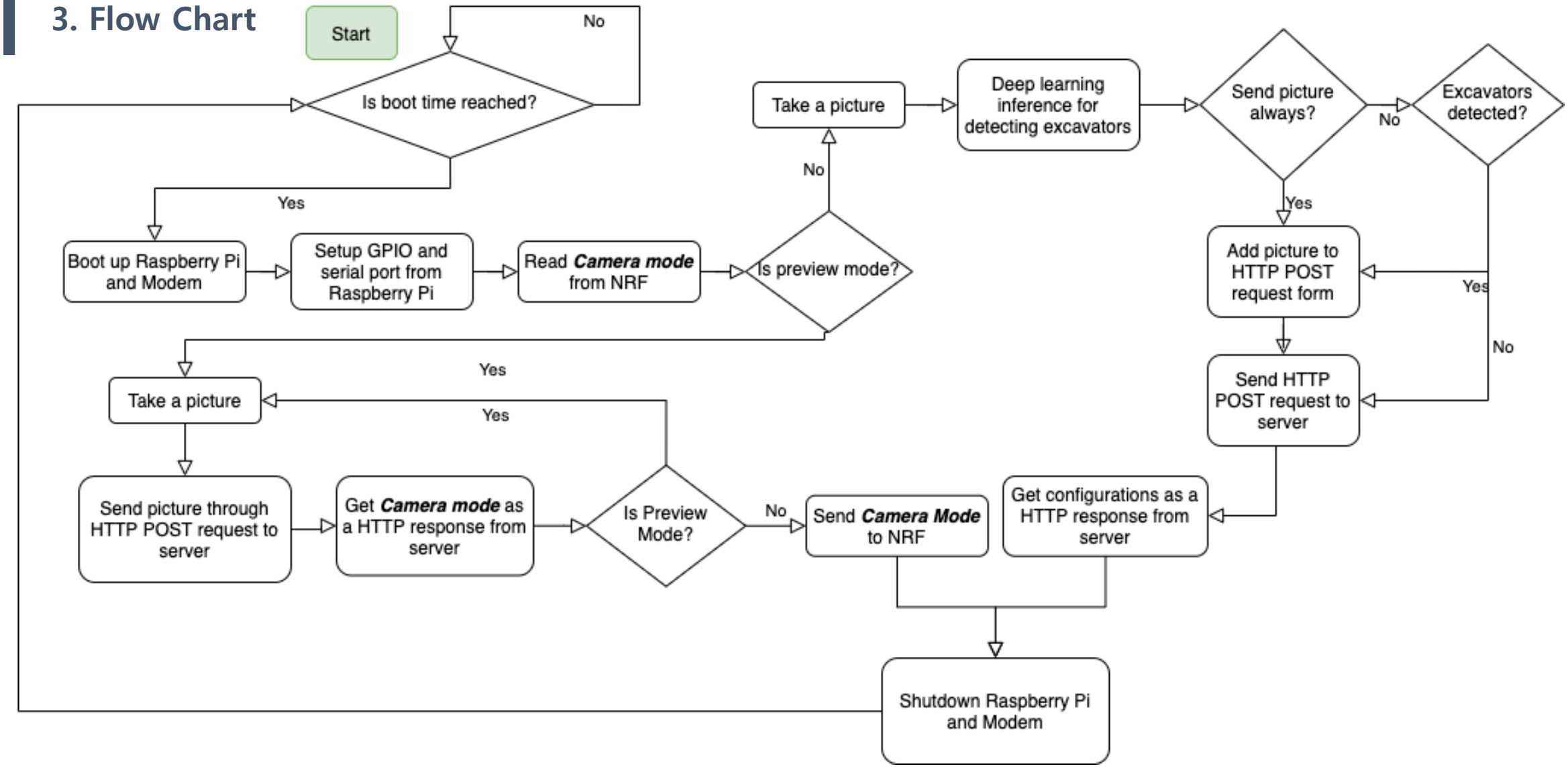
1. 개발환경

개발도구	Git, vscode, vim, cmake
언어	C++
OS 환경	Raspberry Pi OS
Target Device	Codezoo CAT.M1 Modem, NRF Board, Raspberry Pi 4B with Camera
프로젝트 위치	https://github.com/wooseokyourself/object-detection-camera

2. 적용 기술 개요

패키지명	버전	설명
WiringPi	2.52	Raspberry Pi GPIO control
OpenCV	4.5	Image processing and deep learning
JsonCpp	1.9.4	Json parser library for C++
Date	3	Date library for C++
Darknet		Deep learning training framework

3. Flow Chart


Start
Is boot time reached?
No
Yes
Boot up Raspberry Pi and Modem
Setup GPIO and serial port from Raspberry Pi
Read *Camera mode* from NRF
Is preview mode?
No
Yes
Take a picture
Deep learning inference for detecting excavators
Send picture always?
No
Excavators detected?
Yes
Yes
No
Add picture to HTTP POST request form
Send HTTP POST request to server
Take a picture
Yes
Send picture through HTTP POST request to server
Get *Camera mode* as a HTTP response from server
Is Preview Mode?
No
Send *Camera Mode* to NRF
Get configurations as a HTTP response from server
Shutdown Raspberry Pi and Modem

4. UML

Top Level Functions

Name	Parameters	Type	Return
getISOCurrentTimestamp			std::string

GPIO

Methods

Name	Parameters	Type	Return
+ GPIO	_rpiOffPin	const int	
+ ~GPIO			
+ shutdownRpi			
+ isDetectingMode			bool
+ setDetectingMode			

Fields

Name	Type
rpiOffPin	int
rpiModePin	int

Serial

Methods

Name	Parameters	Type	Return
+ Serial			
+ Serial	port baudRate	const char* const int	
+ ~Serial			
+ flush			
+ remaining			int
+ puts	s	const char*	
+ puts	s len	const char* const size_t	
+ getchar			int
+ release			

Fields

Name	Type
fd	int

Config

Methods

Name	Parameters	Type	Return
+ Config			
+ readFromJsonFile	filePath	const std::string	
+ readFromJsonString	jsonString	const std::string	
+ write	filePath	const std::string	
+ getID			std::string
+ getConfThreshold			float
+ getNmsThreshold			float
+ getCaptureWidth			int
+ getIntervalSecs			int
+ sendPictureAlways			bool
+ isPreviewMode			bool

Fields

Name	Type
- deviceId	std::string
- sendInterval	int
- sendOnDetectedOnly	bool
- confidenceThreshold	float
- nmsThreshold	float
- resizeResolution	int
- result	int
- previewMode	bool

YoloObjectDetector

Methods

Name	Parameters	Type	Return
+ YoloObjectDetector			
+ setModel	weightsPath cfgPath namesPath	const std::string const std::string const std::string	
+ getFrameRef			cv::Mat&
+ cloneFrame			cv::Mat
+ extractFrameBytes			std::string
+ extractImagefileBytes	outBytes filePath	std::string& const std::string	
+ resizeFrame	width	const int	
+ writeFrame	filePath	const std::string	bool
+ capture	width	const int	
+ detect	target confThreshold nmsThreshold resize	const int const float const float const int	int
- netPreProcess	resize padSize	const int cv::Size& padSize	
- netPostProcess	target confThreshold nmsThreshold padSize outs	const int const float const float const cv::Size& std::vector<cv::Mat>&	int

Fields

Name	Type
- isSet	bool
- target	int
- frame	cv::Mat
- net	cv::dnn::Net
- outNames	std::vector<cv::String>
- classes	std::vector<std::string>

NRF

Methods

Name	Parameters	Type	Return
+ NRF			
+ NRF	port baudRate	const char* const int	
+ NRF	port baudRate	const std::string const int	
+ ~NRF			
+ getBattery			int
+ setPowerInterval	intervalSecs	const int	

Fields

Name	Type

BG96

Methods

Name	Parameters	Type	Return
+ BG96	port baudRate	const char* const int	
+ BG96	port baudRate	const std::string const int	
+ ~BG96			
+ getRssi			int
+ postMultipart	host uri fields timeoutSecs	std::string std::string HttpPostFormData int	std::string
# putATcmd	cmd	const char*	
# putATcmd	cmd	const std::string	
# putATcmd	cmd len	const char* const size_t	
# putATcmd	cmd len	const std::string const size_t	
# getResponse			std::string
# getResponseUnti	expected timeoutSecs	const std::string const int	std::string

Fields

Name	Type

HttpPostFormData

Methods

Name	Parameters	Type	Return
+ size			
+ clear			
+ addField	_contentType _contentName _content	const std::string const std::string const std::string	
+ changeField	i _contentType _contentName _content	const int const std::string const std::string const std::string	bool
+ getContentType	i	const int	const std::string&
+ getContentName	i	const int	const std::string&
+ getContent	i	const int	const std::string&

Fields

Name	Type
contents	std::vector<MultipartContent>

MultipartContent

Fields

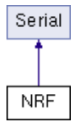
Name	Type
type	std::string
name	std::string
data	std::string

5. 문서

NRF Class Reference

`#include <NRF.hpp>`

Inheritance diagram for NRF:



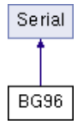
Public Member Functions

	NRF ()
	NRF (const char *port, const int baudRate)
	NRF (const std::string port, const int baudRate)
	~NRF ()
int	**getBattery** () const
void	**setPowerInterval** (const int intervalSecs) const

BG96 Class Reference

`#include <BG96.hpp>`

Inheritance diagram for BG96:



Public Member Functions

	BG96 (const char *port, const int baudRate)
	BG96 (const std::string port, const int baudRate)
	~BG96 ()
int	**getRssi** () Get RSSI of modem through AT command. Try 10 times to get RSSI if AT response is invalid value as RSSI. More...
std::string	**postMultipart** (const std::string host, const std::string uri, const **HttpPostFormData** &fields, const int timeoutSecs) Send HTTP Post request through AT command. More...
void	**putATcmd** (const char *cmd) Send AT command. All AT syntax must be followed. There shouldn't be null character in the command. If it is, use an overridden method that includes "len" in the parameter. More...
void	**putATcmd** (std::string cmd) Send AT command. All AT syntax must be followed. There shouldn't be null character in the command. If it is, use an overridden method that includes "len" in the parameter. More...
void	**putATcmd** (const char *cmd, const size_t len) Send AT command. All AT syntax must be followed. More...
void	**putATcmd** (std::string cmd, const size_t len) Send AT command. All AT syntax must be followed. More...
std::string	**getResponse** () Get AT response. More...
std::string	**waitResponseUntil** (const std::string expected, const int timeoutSecs) Wait AT response until it has sub-string of "expected". More...

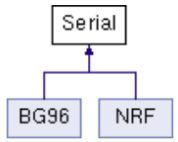
5. 문서

Serial Class Reference

List of all members

`#include <Serial.hpp>`

Inheritance diagram for Serial:



Public Member Functions

Serial ()

Serial (const char *port, const int baudRate)

~Serial ()

Protected Member Functions

void **flush** ()
Flush the serial buffers. (both tx & rx) More...

int **remaining** ()
Return the number of bytes of data available to be read in the serial port. More...

void **puts** (const char *s)
Send a string to the serial port. More...

void **puts** (const char *s, const size_t len)
Send a string to the serial port. More...

int **getchar** ()
Get a single character from the serial device. Note: Zero is a valid character and this function will time-out after 10 secs. More...

void **release** ()
Release the serial port. More...

Protected Attributes

int **fd**

5. 문서

Config Class Reference

`#include <Config.hpp>`

Public Member Functions

	Config ()
void	**readFromJsonFile** (const std::string filePath) Read json from .json file and save it in this object. More...
void	**readFromJsonString** (const std::string jsonString) Read json from string and save it in this object. More...
void	**write** (const std::string filePath) const Write json from this object to file. Not checking for invalid values. More...
std::string	**getID** () const
float	**getConfThreshold** () const
float	**getNmsThreshold** () const
int	**getCaptureWidth** () const
int	**getIntervalSecs** () const
bool	**sendPictureAlways** () const

GPIO Class Reference

`#include <GPIO.hpp>`

Public Member Functions

	GPIO (const int _rpiOffPin, const int _rpiModePin)
void	**shutdownRpi** () Write HIGH into GPIO::rpiOffPin pin for shutting down Raspberry Pi. More...
bool	**isDetectingMode** () Read GPIO::rpiModePin. More...
void	**setDetectingMode** () Write LOW into GPIO::rpiModePin pin. More...

5. 문서

HttpPostFormData Class Reference

`#include <HttpPostFormData.hpp>`

Classes

struct	**MultipartContent**

Public Member Functions

int	**size** () const
void	**clear** () Remove all fields. More...
void	**addField** (const std::string _contentType, const std::string _contentName, const std::string _content) Add one field. Invalid values are not be checked. More...
bool	**changeField** (const int i, const std::string _contentType, const std::string _contentName, const std::string _content) Change one field. Invalid values are not be checked. More...
const std::string &	**getContentType** (const int i) const
const std::string &	**getContentName** (const int i) const
const std::string &	**getContent** (const int i) const

HttpPostFormData::MultipartContent Struct Reference

`#include <HttpPostFormData.hpp>`

Public Attributes

std::string	**type**
std::string	**name**
std::string	**data**

YoloObjectDetector Class Reference

`#include <YoloObjectDetector.hpp>`

Public Member Functions

	YoloObjectDetector ()
void	**setModel** (const std::string weightsPath, const std::string cfgPath, const std::string namesPath) Import YOLOv4 model into this object. More...
Mat &	**getFrameRef** ()
Mat	**cloneFrame** () const
std::string	**extractFrameBytes** () 아직 미작동으로 사용 불가. More...
void	**extractImagefileBytes** (std::string &outBytes, const std::string filePath) Load image file and get its bytes binary. More...
void	**resizeFrame** (const int width) Resize frame with 4:3 ratio. More...
bool	**writeFrame** (const std::string filePath) const Write YoloObjectDetector::frame into file. More...
void	**capture** (const int width) Take a picture of raspi camera with 4:3 ratio and save into YoloObjectDetector::frame. More...
int	**detect** (const int target, const float confThreshold, const float nmsThreshold, const int resize) Run YOLOv4 inference with YoloObjectDetector::frame image. Result image with detected boxes and inference time is saved into YoloObjectDetector::frame. **YoloObjectDetector::setModel()** should be called first. More...

6. 스크린샷

<제품 외형>

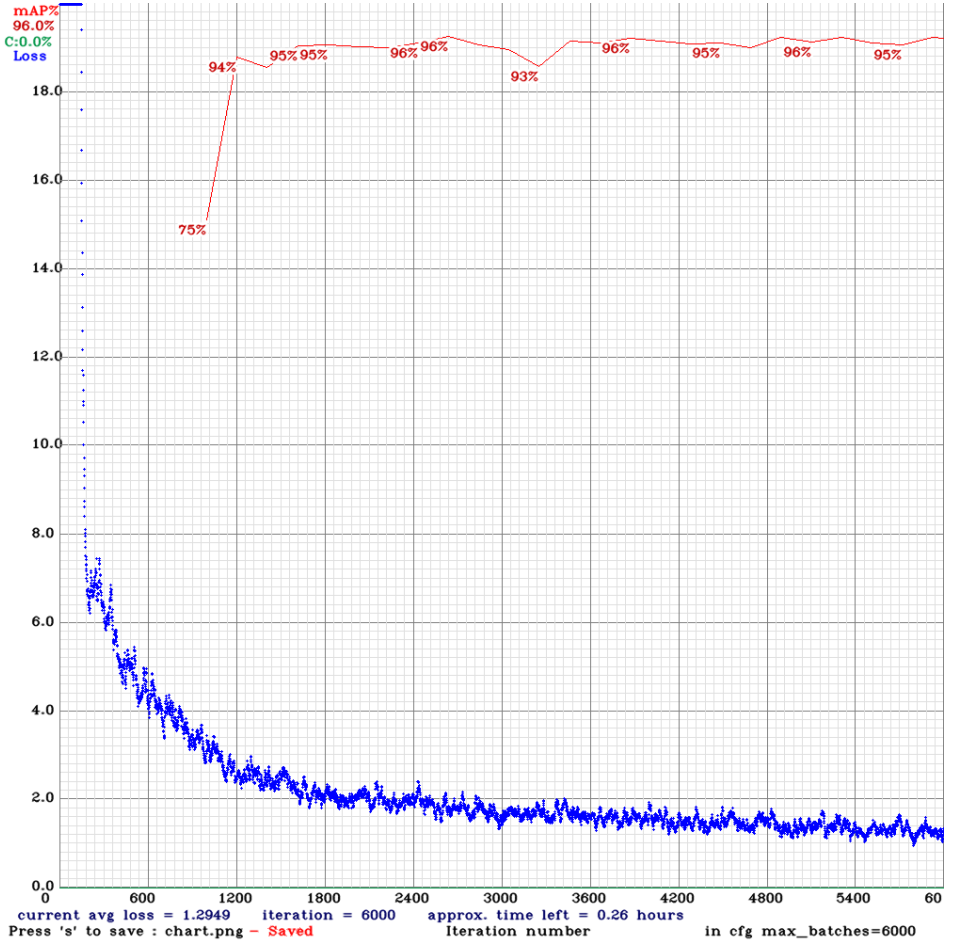
<제품 내부 구조>

6. 스크린샷

last-result.txt

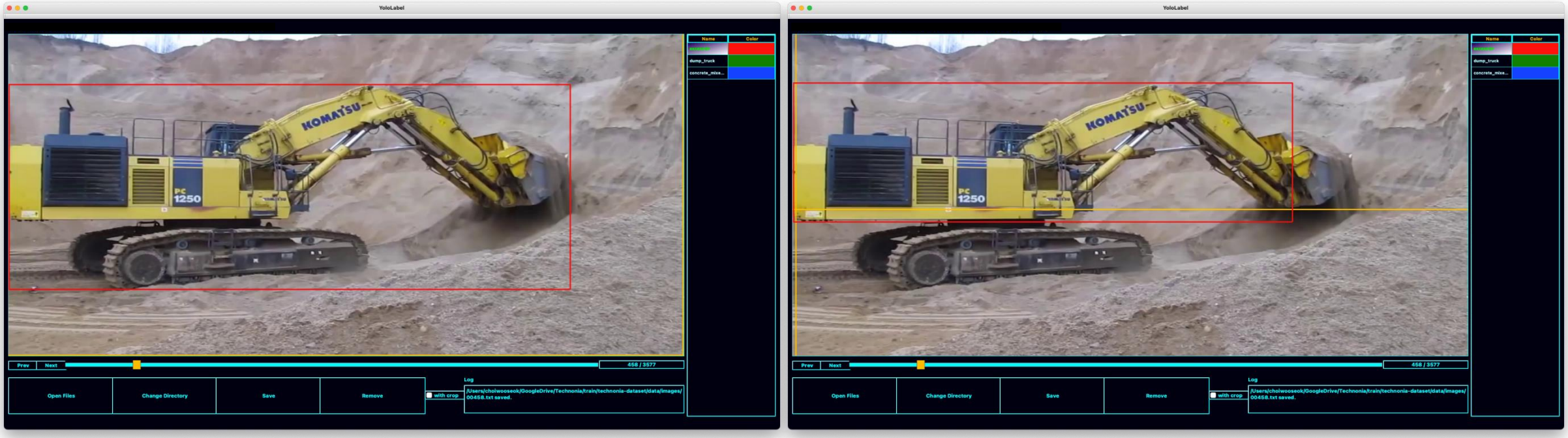
```
 CUDNN_HALF=1
net.optimized_memory = 0
mini_batch = 1, batch = 64, time_steps = 1, train = 0
nms_kind: greedynms (1), beta = 0.600000
nms_kind: greedynms (1), beta = 0.600000
nms_kind: greedynms (1), beta = 0.600000

 seen 64, trained: 384 K-images (6 Kilo-batches_64)

 calculation mAP (mean average precision)...
 Detection layer: 139 - type = 28
 Detection layer: 150 - type = 28
 Detection layer: 161 - type = 28

 detections_count = 1029, unique_truth_count = 578
 rank = 0 of ranks = 1029
 rank = 100 of ranks = 1029
 rank = 200 of ranks = 1029
 rank = 300 of ranks = 1029
 rank = 400 of ranks = 1029
 rank = 500 of ranks = 1029
 rank = 600 of ranks = 1029
 rank = 700 of ranks = 1029
 rank = 800 of ranks = 1029
 rank = 900 of ranks = 1029
 rank = 1000 of ranks = 1029
class_id = 0, name = excavator, ap = 98.15%        (TP = 224, FP = 14)
class_id = 1, name = dump_truck, ap = 92.66%       (TP = 238, FP = 35)
class_id = 2, name = concrete_mixer_truck, ap = 97.13%      (TP = 78, FP = 5)

 for conf_thresh = 0.25, precision = 0.91, recall = 0.93, F1-score = 0.92
 for conf_thresh = 0.25, TP = 540, FP = 54, FN = 38, average IoU = 78.74 %

 IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
 mean average precision (mAP@0.50) = 0.959766, or 95.98 %

Set -points flag:
 `-points 101` for MS COCO
 `-points 11` for PascalVOC 2007 (uncomment `difficult` in voc.data)
 `-points 0` (AUC) for ImageNet, PascalVOC 2010-2012, your custom dataset
```

<딥러닝모델 테스트 결과>



<딥러닝 모델 학습 그래프>

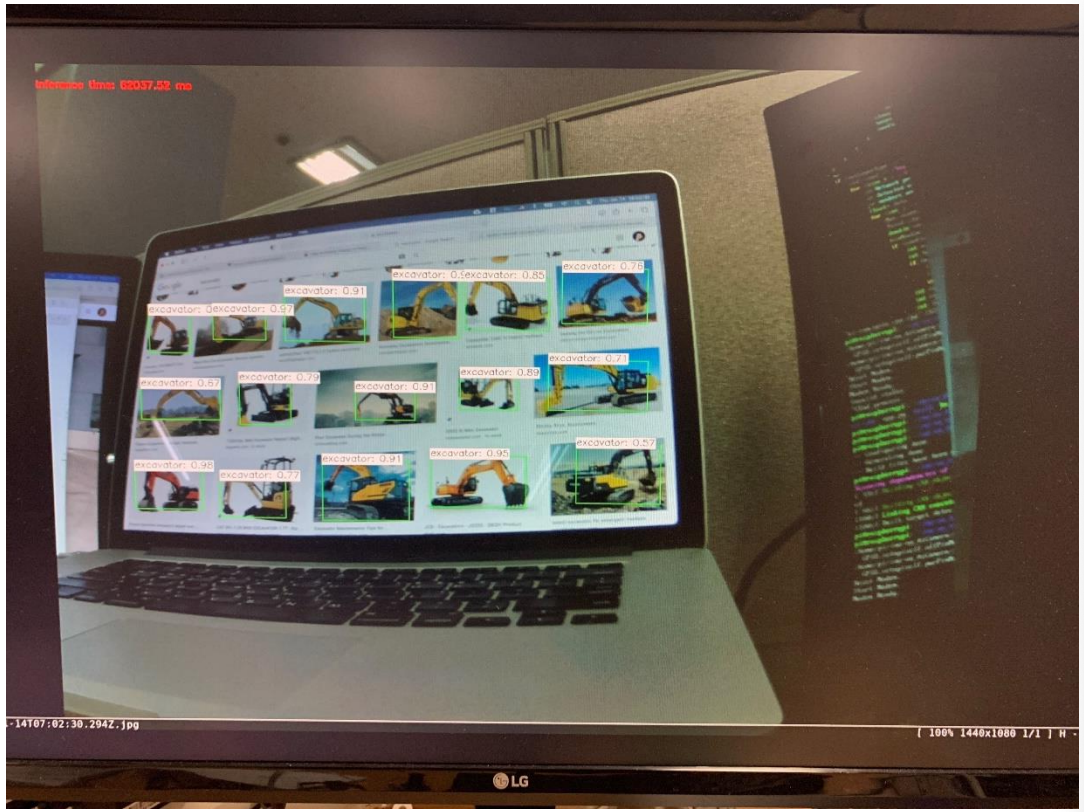
6. 스크린샷



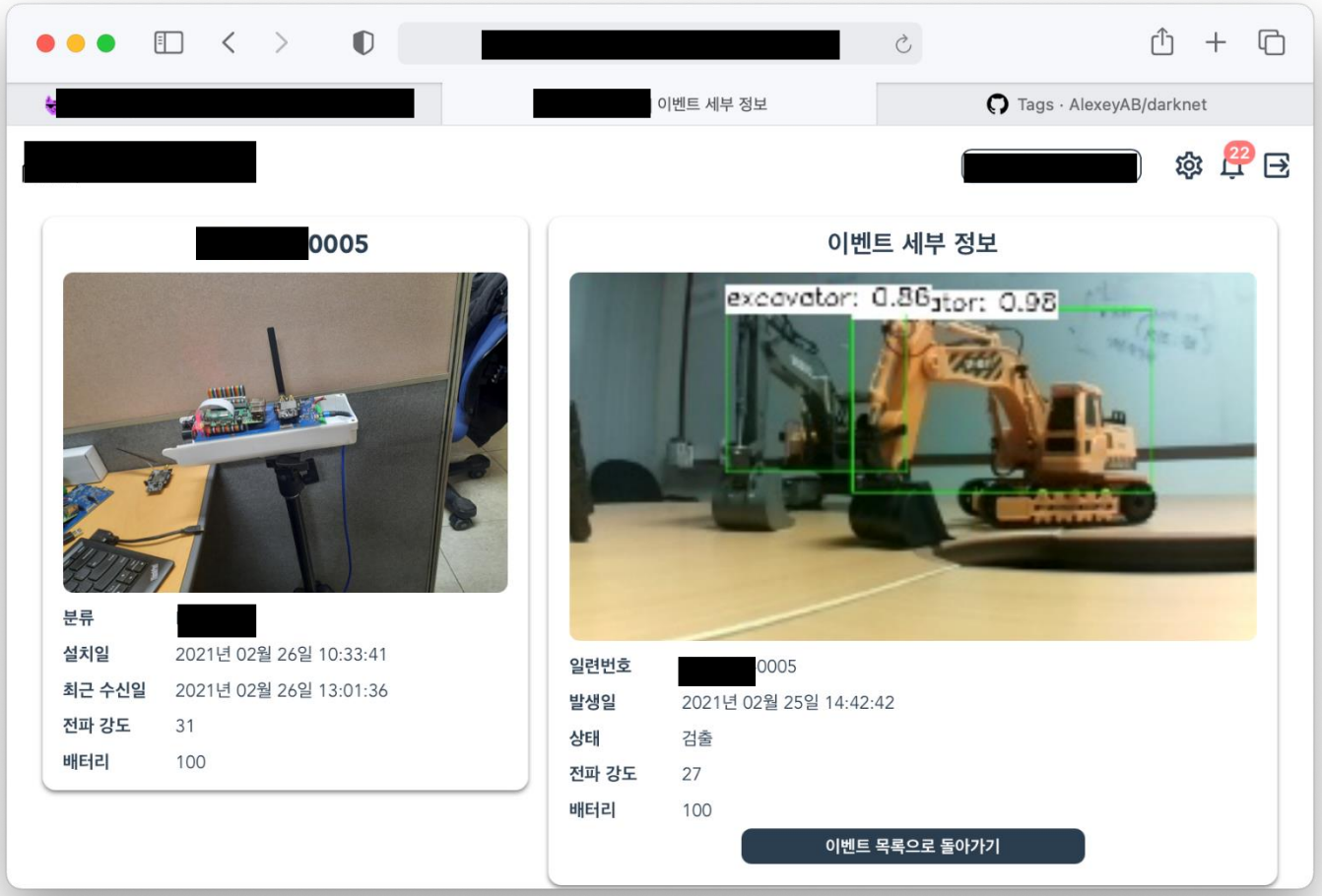
<딥러닝 모델의 최적화를 위한 데이터 라벨링 수정 예>

굴착기의 특징 중 하단의 바퀴와 헤드를 제외하여 학습한 모델을 통해 AI 카메라의 검출 능력 향상

6. 스크린샷



<포크레인 검출 결과>



<서버에서 카메라 작동 결과 조회>