ch 21a. ROS 2

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Outline

◆ **ROS (Robot Operating System) 2 개요**
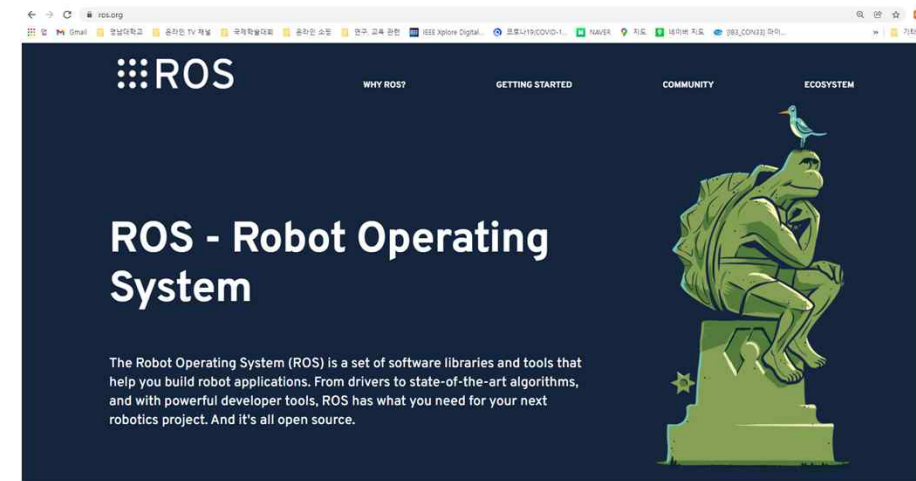◆ **ROS 2 Foxy 설치 - Windows 10**

ROS2 개요

ROS 소개

◆ **Robot Operating System (ROS)**
- https://www.ros.org/
- http://wiki.ros.org/ROS/Tutorials
- http://wiki.ros.org/catkin/Tutorials
- 로봇을 위한 "메타" 오퍼레이팅 시스템
- 패키징, 빌드 툴을 포함
- 분산된 프로세스/머신 간의 통신 및 구성을 위한 아키텍처
- 시스템 런-타임과 데이터 분석을 위한 개발 도구
- 개발 언어에 독립된 아키텍처
  - C++, Python, Lisp, Java, 등.

◆ **ROS는 아래 내용을 의미하지 않는다**
- 실제 오퍼레이팅 시스템
- 프로그래밍 언어
- 프로그래밍 환경 / IDE
- Hard real-time 아키텍처

ROS - Robot Operating System

The Robot Operating System (ROS) is a set of software libraries and tools that help you build robot applications. From drivers to state-of-the-art algorithms, and with powerful developer tools, ROS has what you need for your next robotics project. And it's all open source.

ROS 소개

◆ What is ROS (Robot Operating System)

- a <u>software framework</u> for programming robots
- prototypes originated from Stanford AI research, officially created and developed by Willow Garage (robotics research Lab. and incubator) starting in 2007 (source: https://en.wikipedia.org/wiki/Willow_Garage)
- Currently maintained by Open Source Robotics Foundation
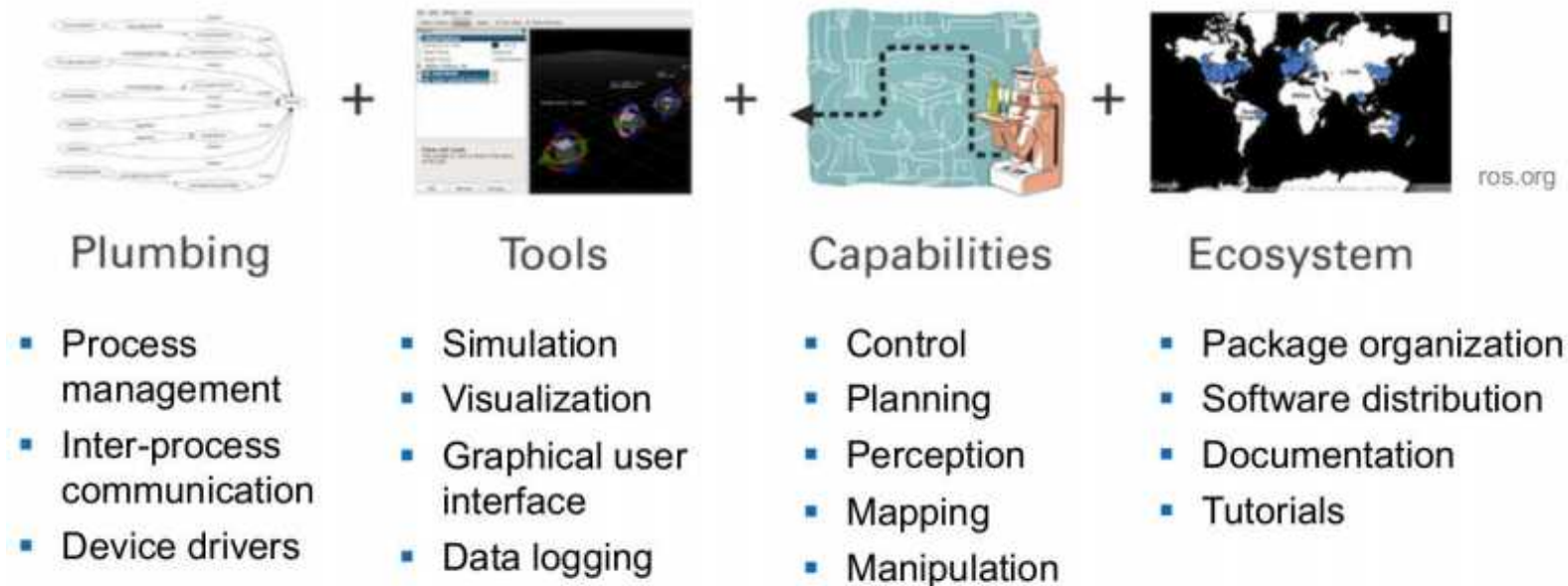- Consists of infrastructure, tools, capabilities, and ecosystem

ROS 소개

◆ **Robot Operating System (ROS)**

● https://www.ros.org/

ROS = Robot Operating System

Plumbing
- Process management
- Inter-process communication
- Device drivers

Tools
- Simulation
- Visualization
- Graphical user interface
- Data logging

Capabilities
- Control
- Planning
- Perception
- Mapping
- Manipulation

Ecosystem
- Package organization
- Software distribution
- Documentation
- Tutorials

Slide Credit: Marco Hutter, ETH Zurich

차세대 네트워킹 연구실
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교수 김 영 탁

Advantages and Disadvantages of ROS

Advantages	Disadvantages
- provides lots of infrastructure, tools, and capabilities - easy to try other people's work and share your own - large community - free, open source, BSD license	- approaching maturity, but still changing - security and scalability are not first-class concerns - OSes other than Ubuntu Linux are not well supported
great for open-source and researchers	not great for mission-critical tasks => ROS2에서 기능 추가

ROS is a Meta-Operating System

◆메타운영체제(Meta-Operating System):

- 어플리케이션과 분산 컴퓨팅 자원 간의 가상화 레이어로 분산 컴퓨팅 자원을 활용하여, scheduling 및 로드, 감시, 에러 처리 등을 실행하는 시스템

- 즉, 윈도우, 리눅스, 안드로이드와 같은 전통적인 운영체제는 아니며, ROS는 기존의 전통적인 운영체제(리눅스, 윈도우, OS-X, 안드로이드)를 이용하고 있다.

- 기존 운영체제의 프로세스 관리 시스템, 파일 시스템, 유저 인터페이스, 프로그램 유틸(컴파일러, 스레드 모델 등)등을 사용

- 추가적으로 다수의 이기종 하드웨어 간의 데이터 송수신, scheduling, 에러 처리 등 로봇 응용 소프트웨어를 위한 필수 기능 들을 라이브러리 형태로 제공

- 기존 로봇 소프트웨어 프레임 워크를 기반으로 다양한 목적의 응용 프로그램을 개발, 관리, 제공하고 있으며 사용자 (user)들이 개발한 패키지 또한 유통하는 생태계(ecosystem)를 갖추고 있음

Meta-Operating System

디바이스 드라이버, 라이브러리, 디버그 도구, 메시지 통신
구동 도구, 컴파일 도구, 인스톨러, 패키지 생성 및 릴리즈

ROBOT ⟷ 메타 운영체제 ⟷ SENSOR

APP

Reference: https://www.slideshare.net/yoonseokpyo/20160406-ros-1-for

ROS(Robot Operating System)

◆ROS Framework

- 가벼움: ROS는 가볍게 설계되어 ROS용으로 작성된 코드를 다른 로봇 소프트웨어 framework에 사용 가능

- ROS에 의존적이지 않은 라이브러리: 라이브러리를 개발할 때, 명확하고 기능적인 인터페이스를 갖는 ROS에 의존적이지 않도록 개발하는 것을 선호

- 언어 독립성: ROS framework은 최신의 어떤 언어로도 쉽게 구현할 수 있음

- 쉬운 테스트: ROS는 ros test라고 하는 단위/통합 테스트 framework 기반 위에 있는데, 설치 및 제거가 아주 쉬움

- 규모 적응성: ROS는 대규모 실행 시스템 및 개발 프로세스에도 적용 가능

ROS(Robot Operating System)

◆ 지원 운영체제
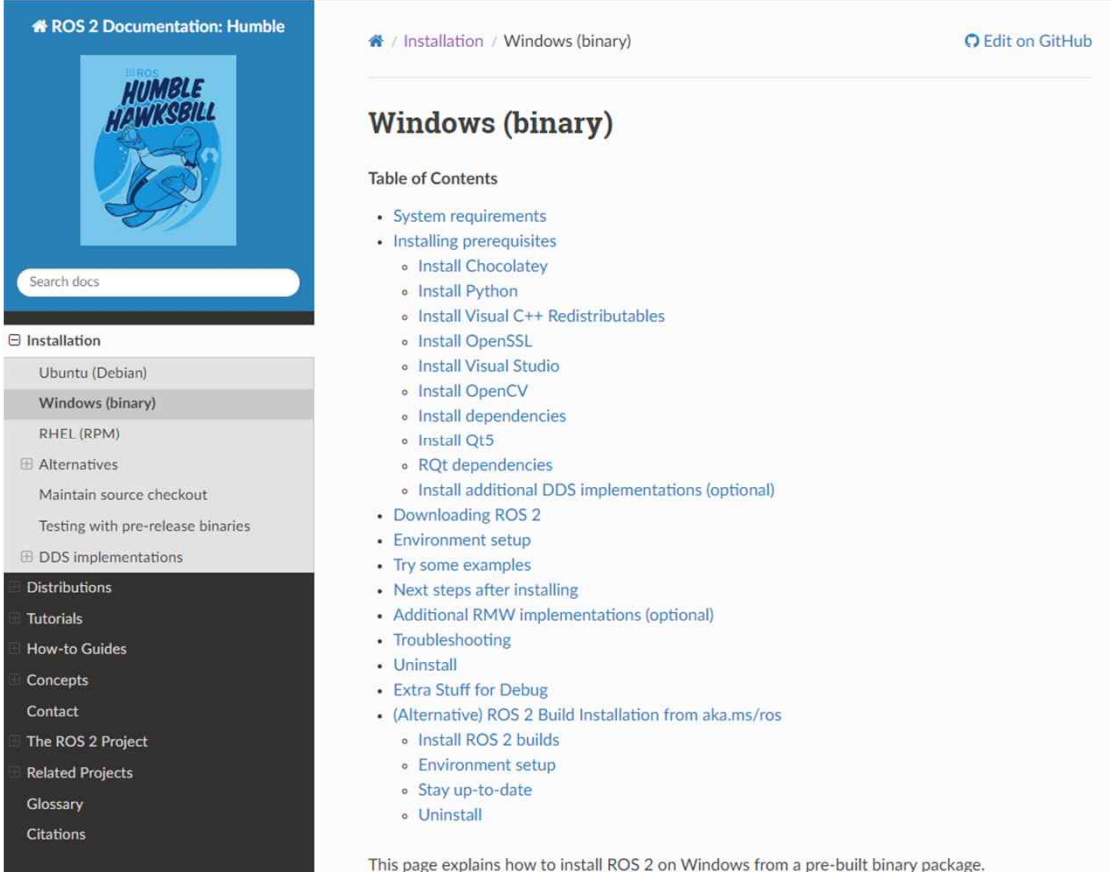
- ROS를 사용 가능한 운영체제(OS)로는 Ubuntu, OS X, Windows, Fedora, Gentoo, OpenSUSE, Debian, Raspbian, Arch, QNX Realtime OS 등이 있으나 기능 제한사항이 있을 수 있음
- 스마트폰 운영체제인 Android, iOS 의 경우, 부분적 사용 가능
- OS를 탑재할 수 없는 마이크로 컨트롤러 유닛(MCU)의 경우, Serial 통신, Bluetooth, LAN 경유로 통신할 수 있는 라이브러리 제공
- 기본적으로는 Ubuntu, OS X 에서 구동하는 것을 추천!
- ROS2는 Windows 10에 설치 가능

ROS 2 Humle Hawksbill on Windows 10

◆ ROS 2 Humble Hawksbill on Windows 10

- https://www.ros.org/

- https://docs.ros.org/en/humble/Installation/Windows-Install-Binary.html

- **Install ROS on windows 10 without VM,**
  https://www.youtube.com/watch?v=jEFA8bjL1Iw&list=PLFGU0Ebtn7y4p1BPF8My_SxRZSlcMSGAd&index=3

Ubuntu버전에 따른 ROS버전 선택

ROS Distribution	Supported OS	Experimental OS
Melodic Morenia	Ubuntu 18.04(LTS); Debian9	OS X(Homebrew), Gentoo, Ubuntu ARM, and OpenEmbedded/Yocto
Kinetic Kame	Ubuntu 16.34(LTS) and 15.10; Debian 8	OS X(Homebrew), Gentoo, Ubuntu ARM, and OpenEmbedded/Yocto
Jade Turtle	Ubuntu 15.04,14.10, and 14.04; Debian 8	OS X(Homebrew), Gentoo, Arch Linux, Android NDK, Ubuntu ARM, OpenEmbedded/Yocto
Indigo Igloo (LTS)	Ubuntu 14.04(LTS) and 13.10; Debian 7	OS X(Homebrew), Gentoo, Arch Linux, Android NDK, Ubuntu ARM, OpenEmbedded/Yocto

ROS를 사용하는 이유

◆ **소프트웨어 측면의 많은 문제들을 해결하기 위해 설계**

◆ **광범위한 센서, 액추에이터를 지원하는 일련의 라이브러리를 포함**

◆ **쉬운 하드웨어 인터페이스 제공**
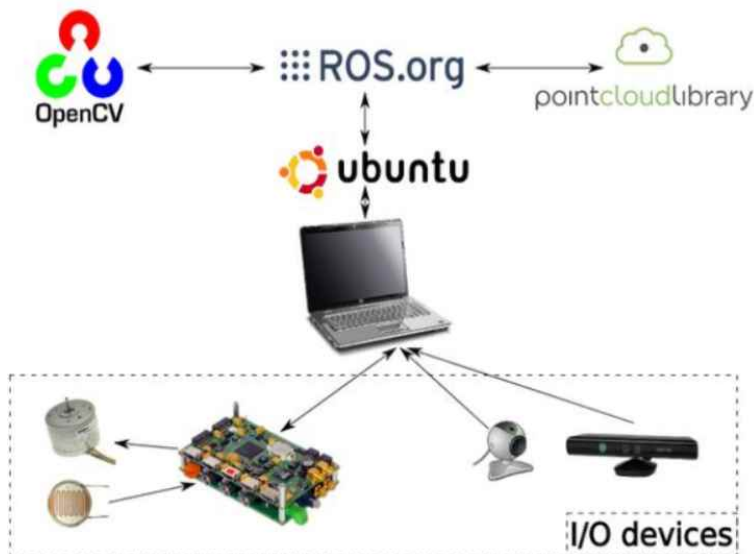
ROS2

◆ ROS 2

- DDS (Data Distribution Service)사용으로 Master 기능없이 응용 프로그램 구성
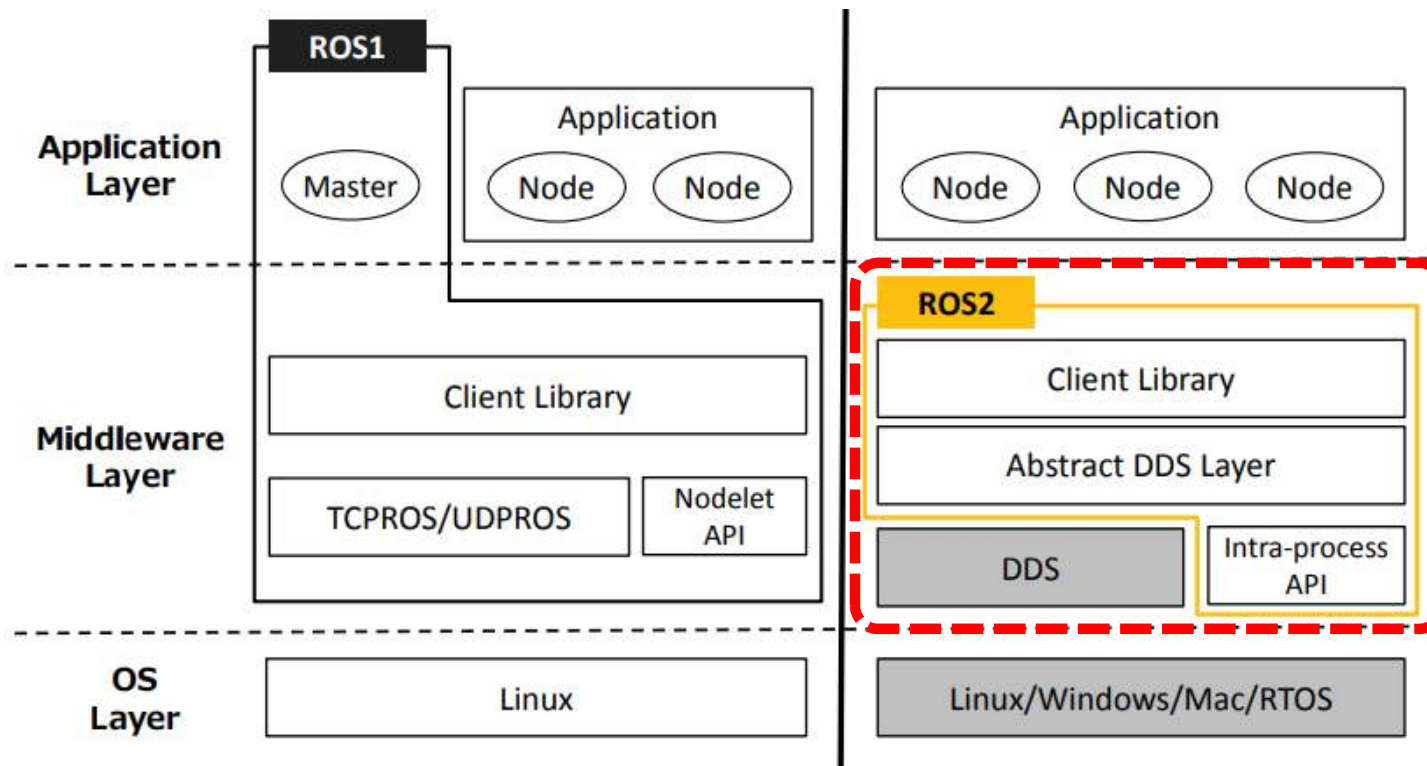
Windows 10 컴퓨터에 ROS2 설치

ROS 설치

◆ ROS 및 관련 패키지 설치

- Jetson Nano : ROS Melodic
- Raspberry Pi : ROS noetic

ROS 2 Foxy를 Windows 10에 설치

◆ **ROS 2 관련 교육자료**

- https://puzzling-cashew-c4c.notion.site/ROS-2-for-G-Camp-6f86b29e997e445badb69cc0af825a71
- https://github.com/Road-Balance/gcamp_ros2_basic

◆ **Chocolatey를 사용하여 설치**

- https://chocolatey.org/install
- Windows PowerShell (Windows + X + A)
- Set-ExecutionPolicy Bypass -Scope Process -Force; [System.Net.ServicePointManager]::SecurityProtocol = [System.Net.ServicePointManager]::SecurityProtocol -bor 3072; iex ((New-Object System.Net.WebClient).DownloadString('https://community.chocolatey.org/install.ps1'))

ROS 2 Foxy를 Windows 10에 설치

◆ Chocolatey를 사용하여 설치 (계속)

ROS 2 Foxy를 Windows 10에 설치

◆ Windows Terminal 설치

● Windows PowerShell ->
  choco install -y microsoft-windows-terminal

Windows Terminal 사용

◆ Windows

- ● Terminal을 관리자 권한으로 실행
  - ▪ 오른쪽 마우스 버튼 클릭 ->
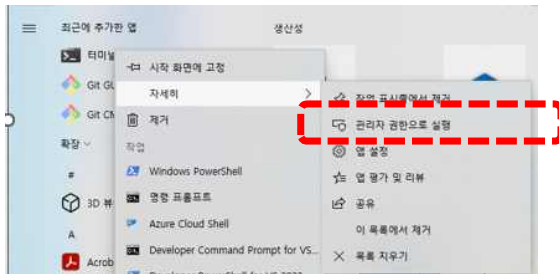
Windows Terminal의 분할 방법
- ▪ 화면 수평 분할: alt + shift + '+'
- ▪ 화면 수직 분할: alt + shift + '-'
- ▪ 자동화면분할 : alt + shift + 'D'
- ▪ 화면간 이동 : alt + 화살표 키
- ▪ 화면 분할 종료 : ctrl + shift + 'w'

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고급스 프로그래밍
교수 김 영 탁
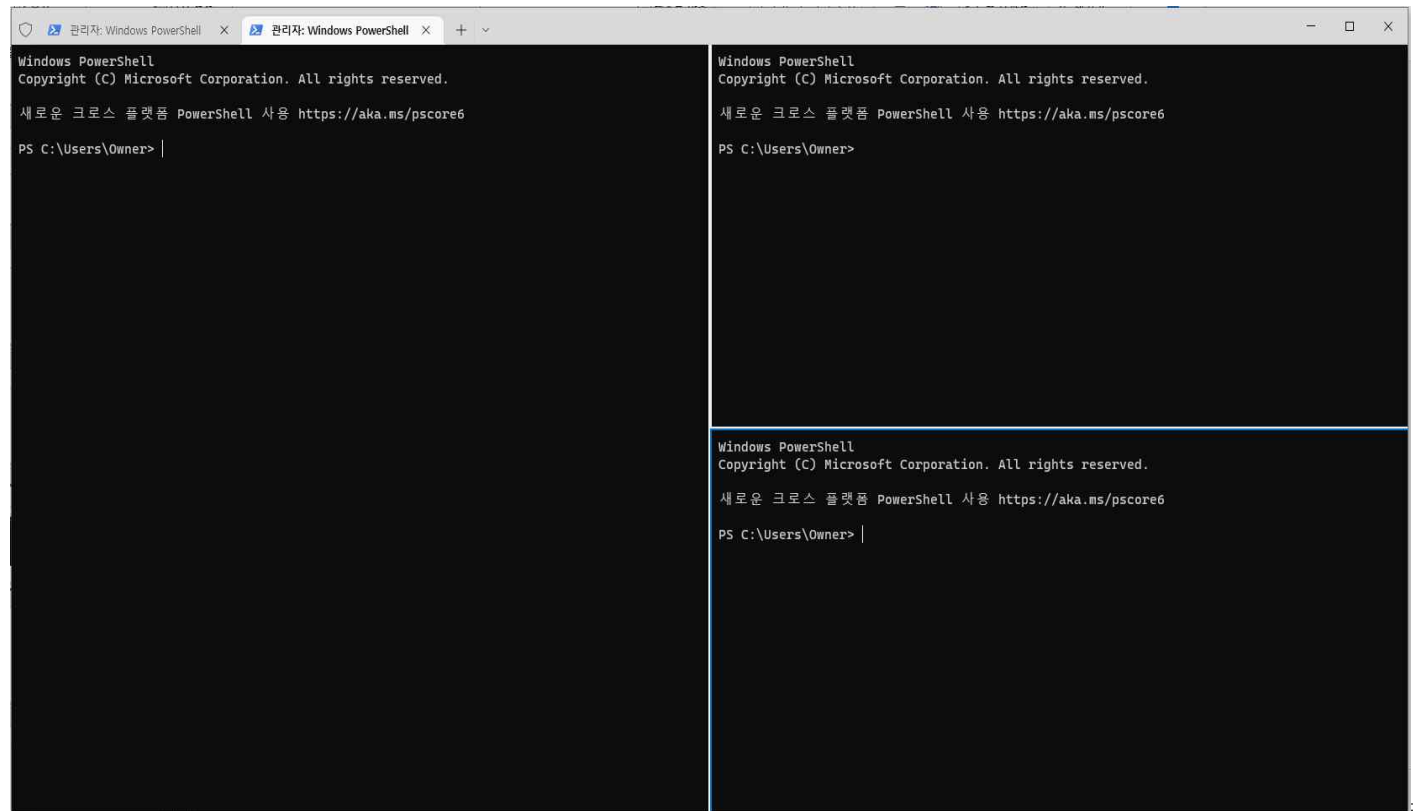
Python 3.8.3 설치

◆ **Windows Terminal에서 Chocolatey를 사용하여 Python 3.8.3 설치**

> choco install -y python --version 3.8.3

Git 설치

◆ **Windows Terminal에서 Chocolatey를 사용하여 Git설치**

> choco install git

Visual C++ Redistributables 설치

◆ Windows Terminal에서 Chocolatey를 사용하여 설치

> choco upgrade --checksum64
      F3B7A76D84D23F91957AA18456A14B4E90609E4CE8194C5653384ED38DADA6F3 --
      checksum
      99DCE3C841CC6028560830F7866C9CE2928C98CF3256892EF8E6CF755147B0D8
      vcredist2010

> choco install -y vcredist2010 vcredist2013 vcredist140

```
PS C:\Users\Owner> choco upgrade --checksum64 F3B7A76D84D23F91957AA18456A14B4E90609E4CE8194C5653384ED38DADA6F3 --checksum
99DCE3C841CC6028560830F7866C9CE2928C98CF3256892EF8E6CF755147B0D8 vcredist2010
Chocolatey v1.3.0
Upgrading the following packages:
vcredist2010
By upgrading, you accept licenses for the packages.
vcredist2010 is not installed. Installing...
Progress: Downloading vcredist2010 10.0.40219.32503... 100%
Progress: Downloading vcredist2010 10.0.40219.32503... 100%

vcredist2010 v10.0.40219.32503 [Approved]
vcredist2010 package files upgrade completed. Performing other installation steps.
The package vcredist2010 wants to run 'chocolateyInstall.ps1'.
Note: If you don't run this script, the installation will fail.
Note: To confirm automatically next time, use '-y' or consider:
choco feature enable -n allowGlobalConfirmation
```
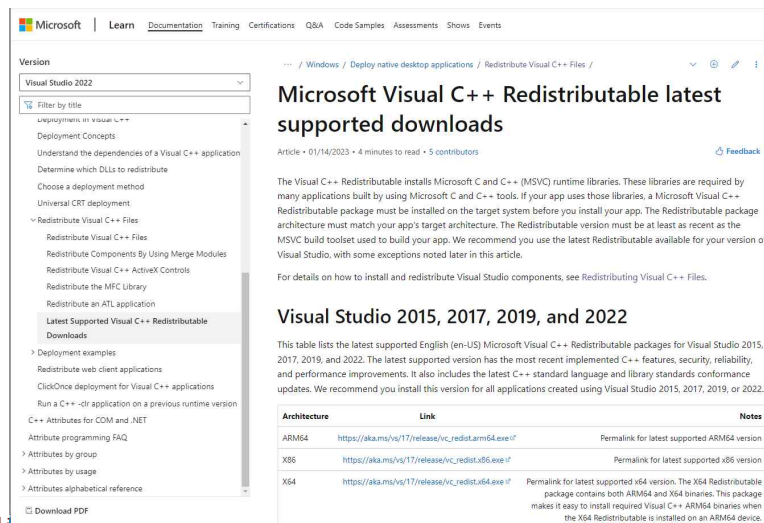
```
Do you want to run the script?([Y]es/[A]ll - yes to all/[N]o/[P]rint): y

Downloading vcredist2010 64 bit
  from 'https://download.microsoft.com/download/1/6/5/165255E7-1014-4D0A-B094-B6A430A6BFFC/vcredist_x64.exe'
Progress: 100% - Completed download of C:\Users\Owner\AppData\Local\Temp\chocolatey\vcredist2010\10.0.40219.32503\vcredist
_x64.exe (9.8 MB).
Download of vcredist_x64.exe (9.8 MB) completed.
Hashes match.
Installing vcredist2010...
vcredist2010 has been installed.
Downloading vcredist2010 32 bit
  from 'https://download.microsoft.com/download/1/6/5/165255E7-1014-4D0A-B094-B6A430A6BFFC/vcredist_x86.exe'
Progress: 100% - Completed download of C:\Users\Owner\AppData\Local\Temp\chocolatey\vcredist2010\10.0.40219.32503\vcredist
_x86.exe (8.58 MB).
Download of vcredist_x86.exe (8.58 MB) completed.
Hashes match.
Installing vcredist2010...
vcredist2010 has been installed.
 The upgrade of vcredist2010 was successful.
  Software installed as 'exe', install location is likely default.

Chocolatey upgraded 1/1 packages.
 See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).

Enjoy using Chocolatey? Explore more amazing features to take your
experience to the next level at
 https://chocolatey.org/compare
```

```
PS C:\Users\Owner> choco install -y vcredist2010 vcredist2013 vcredist140
Chocolatey v1.3.0
Installing the following packages:
vcredist2010;vcredist2013;vcredist140
By installing, you accept licenses for the packages.
vcredist2010 v10.0.40219.32503 already installed.
 Use --force to reinstall, specify a version to install, or try upgrade.
Progress: Downloading vcredist2013 12.0.40660.20180427... 100%

vcredist2013 v12.0.40660.20180427 [Approved]
vcredist2013 package files install completed. Performing other installation steps.
Downloading vcredist2013 64 bit
  from 'https://download.microsoft.com/download/0/5/6/056dcda9-d667-4e27-8001-8a0c6971d6b1/vcredist_x64.exe'
Progress: 100% - Completed download of C:\Users\Owner\AppData\Local\Temp\chocolatey\vcredist2013\12.0.40660.20180427\vcred
ist_x64.exe (6.87 MB).
Download of vcredist_x64.exe (6.87 MB) completed.
Hashes match.
Installing vcredist2013...
vcredist2013 has been installed.
Downloading vcredist2013
  from 'https://download.microsoft.com/download/0/5/6/056dcda9-d667-4e27-8001-8a0c6971d6b1/vcredist_x86.exe'
Progress: 100% - Completed download of C:\Users\Owner\AppData\Local\Temp\chocolatey\vcredist2013\12.0.40660.20180427\vcred
ist_x86.exe (6.21 MB).
Download of vcredist_x86.exe (6.21 MB) completed.
Hashes match.
Installing vcredist2013...
vcredist2013 has been installed.
  vcredist2013 can be automatically uninstalled.
 The install of vcredist2013 was successful.
  Software installed as 'exe', install location is likely default.
vcredist140 v14.34.31938 already installed.
 Use --force to reinstall, specify a version to install, or try upgrade.

Chocolatey installed 1/3 packages.
 See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).

Warnings:
 - vcredist2010 - vcredist2010 v10.0.40219.32503 already installed.
 Use --force to reinstall, specify a version to install, or try upgrade.
 - vcredist140 - vcredist140 v14.34.31938 already installed.
 Use --force to reinstall, specify a version to install, or try upgrade.
PS C:\Users\Owner> |
```

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교수 김 영 탁

OpenSSL 설치

## ◆ OpenSSL (https://www.openssl.org/)

- OpenSSL is a software library for applications that provide secure communications over computer networks against eavesdropping or need to identify the party at the other end. It is widely used by Internet servers, including the majority of HTTPS websites.

- https://slproweb.com/products/Win32OpenSSL.html

File	Type	Description
Win64 OpenSSL v3.0.8 Light EXE | MSI	5MB Installer	Installs the most commonly used essentials of Win64 OpenSSL v3.0.8 (Recommended for users by the creators of OpenSSL). Only installs on 64-bit versions of Windows and targets Intel x64 chipsets. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.
Win64 OpenSSL v3.0.8 EXE | MSI	140MB Installer	Installs Win64 OpenSSL v3.0.8 (Recommended for software developers by the creators of OpenSSL). Only installs on 64-bit versions of Windows and targets Intel x64 chipsets. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.
Win32 OpenSSL v3.0.8 Light EXE | MSI	4MB Installer	Installs the most commonly used essentials of Win32 OpenSSL v3.0.8 (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.
Win32 OpenSSL v3.0.8 EXE | MSI	116MB Installer	Installs Win32 OpenSSL v3.0.8 (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.
Win64 OpenSSL v3.0.8 Light for ARM (EXPERIMENTAL) EXE | MSI	5MB Installer	Installs the most commonly used essentials of Win64 OpenSSL v3.0.8 for ARM64 devices (Only install this VERY EXPERIMENTAL build if you want to try 64-bit OpenSSL for Windows on ARM processors. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.
Win64 OpenSSL v3.0.8 for ARM (EXPERIMENTAL) EXE | MSI	113MB Installer	Installs Win64 OpenSSL v3.0.8 for ARM64 devices (Only install this VERY EXPERIMENTAL build if you want to try 64-bit OpenSSL for Windows on ARM processors. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation.

OpenSSL 설치 확인

◆ OpenSSL 설치 확인
- OpenSSL의 설치 위치 확인
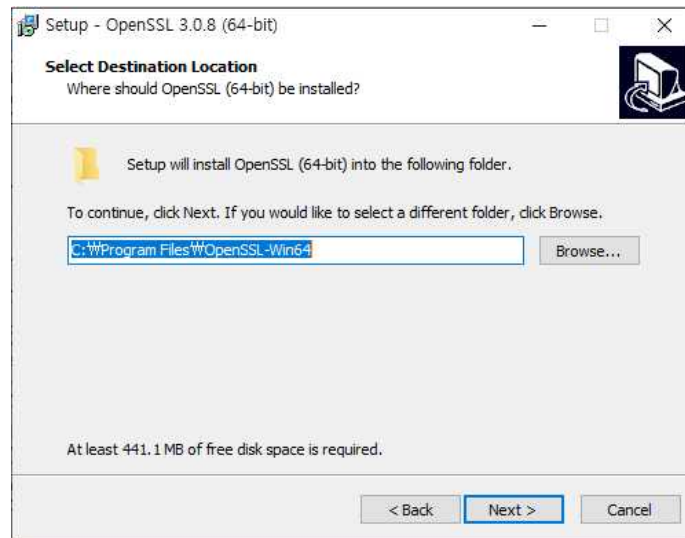
◆ PowerShell에서 OpenSSL 설치 확인
- setx -m OPENSSL_CONF "C:\Program Files\OpenSSL-Win64\bin\openssl.cfg"

Path에 OpenSSL 추가

◆ 제어판 -> 시스템 및 보안 -> 시스템 ->고급시스템 설정
-> 환경변수 -> Path -> 새로 만들기 -> 다음 항목을 붙여넣기

● *C:\Program Files\OpenSSL-Win64\bin\openssl.cfg*

Visual Studio 2019 설치

◆ Visual Studio 2019 설치

- https://visualstudio.microsoft.com/ko/vs/older-downloads/

CMake 설치

◆ CMake 설치

> choco install -y cmake

```
PS C:\Users\Owner> choco install -y cmake
Chocolatey v1.3.0
Installing the following packages:
cmake
By installing, you accept licenses for the packages.
Progress: Downloading cmake.install 3.25.2... 100%
Progress: Downloading cmake 3.25.2... 100%

cmake.install v3.25.2 [Approved]
cmake.install package files install completed. Performing other installation steps.
Installing 64-bit cmake.install...
cmake.install has been installed.
  cmake.install may be able to be automatically uninstalled.
 The install of cmake.install was successful.
  Software installed to 'C:\Program Files\CMake\'

cmake v3.25.2 [Approved]
cmake package files install completed. Performing other installation steps.
 The install of cmake was successful.
  Software installed to 'C:\ProgramData\chocolatey\lib\cmake'

Chocolatey installed 2/2 packages.
 See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).
PS C:\Users\Owner>
```

추가 종속성 패키지 설치 (2)

◆ Nuget Packages 추가 설치

- dos2_downloads 폴더 생성
- Github (https://github.com/ros2/choco-packages/releases/tag/2020-02-24)에서 패키지 download (log4cxx.0.10.0.2.nupkg는 제외)
- download (다운로드) 폴더에서 dos2_downloads로 이동

▼ Assets 10

asio.1.12.1.nupkg	791 KB	Feb 25, 2020
bullet.2.89.0.nupkg	25 MB	Feb 25, 2020
cunit.2.1.3.nupkg	72 KB	Feb 25, 2020
eigen.3.3.4.nupkg	1010 KB	Feb 25, 2020
log4cxx.0.10.0-2.nupkg	3.8 MB	Feb 25, 2020
log4cxx.0.10.0.nupkg	3.89 MB	Feb 25, 2020
tinyxml-usestl.2.6.2.nupkg	393 KB	Feb 25, 2020
tinyxml2.6.0.0.nupkg	307 KB	Feb 25, 2020
Source code (zip)		Feb 25, 2020
Source code (tar.gz)		Feb 25, 2020

|			
asio.1.12.1.nupkg	2023-02-17 오전 7:14	NUPKG 파일	792KB
bullet.2.89.0.nupkg	2023-02-17 오전 7:14	NUPKG 파일	25,554KB
choco-packages-2020-02-24.tar	2023-02-17 오전 7:14	ALZip GZ File	5,619KB
choco-packages-2020-02-24	2023-02-17 오전 7:14	ALZip ZIP File	5,664KB
cunit.2.1.3.nupkg	2023-02-17 오전 7:14	NUPKG 파일	73KB
eigen.3.3.4.nupkg	2023-02-17 오전 7:14	NUPKG 파일	1,006KB
log4cxx.0.10.0.nupkg	2023-02-17 오전 7:14	NUPKG 파일	3,979KB
tinyxml2.6.0.0.nupkg	2023-02-17 오전 7:14	NUPKG 파일	308KB
tinyxml-usestl.2.6.2.nupkg	2023-02-17 오전 7:14	NUPKG 파일	393KB

추가 종속성 패키지 설치 (2)

◆ Nuget Packages 추가 설치

● choco install -y -s **C:\ros2_downloads** asio cunit eigen tinyxml-usestl tinyxml2 log4cxx bullet

```
PS C:\Users\Owner> choco install -y -s C:\ros2_downloads asio cunit eigen tinyxml-usestl tinyxml2 log4cxx bullet
Chocolatey v1.3.0
Installing the following packages:
asio;cunit;eigen;tinyxml-usestl;tinyxml2;log4cxx;bullet
By installing, you accept licenses for the packages.
```

. . . .

```
Chocolatey installed 7/7 packages.
 See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).

Installed:
 - tinyxml2 v6.0.0
 - asio v1.12.1
 - cunit v2.1.3
 - bullet v2.89.0
 - tinyxml-usestl v2.6.2
 - eigen v3.3.4
 - log4cxx v0.10.0

Enjoy using Chocolatey? Explore more amazing features to take your
experience to the next level at
  https://chocolatey.org/compare
PS C:\Users\Owner> |
```

파이썬 관련 패키지 Upgrade 및 설치

◆ **파이썬 관련 패키지 Upgrade 및 설치**

> python -m pip install --upgrade pip

> python -m pip install -U catkin_pkg cryptography empy ifcfg lark-parser lxml netifaces
   numpy opencv-python pyparsing pyyaml setuptools rosdistro

> python -m pip install -U pydot PyQt5

```
PS C:\Users\Owner> python -m pip install --upgrade pip
Requirement already satisfied: pip in c:\users\owner\appdata\local\programs\python\python39\lib\site-packages (23.0)
PS C:\Users\Owner> python -m pip install -U catkin_pkg cryptography empy ifcfg lark-parser lxml netifaces numpy opencv-pyt
hon pyparsing pyyaml setuptools rosdistro
Collecting catkin_pkg
  Downloading catkin_pkg-0.5.2-py3-none-any.whl (76 kB)
                                        76.1/76.1 kB 4.1 MB/s eta 0:00:00
```

```
PS C:\Users\Owner> python -m pip install -U pydot PyQt5
Collecting pydot
  Downloading pydot-1.4.2-py2.py3-none-any.whl (21 kB)
Collecting PyQt5
  Downloading PyQt5-5.15.9-cp37-abi3-win_amd64.whl (6.8 MB)
                                        6.8/6.8 MB 11.5 MB/s eta 0:00:00
Requirement already satisfied: pyparsing>=2.1.4 in c:\users\owner\appdata\local\programs\python\python39\lib\site-packages
 (from pydot) (3.0.9)
Collecting PyQt5-Qt5>=5.15.2
  Downloading PyQt5_Qt5-5.15.2-py3-none-win_amd64.whl (50.1 MB)
                                        50.1/50.1 MB 10.7 MB/s eta 0:00:00
Collecting PyQt5-sip<13,>=12.11
  Downloading PyQt5_sip-12.11.1-cp39-cp39-win_amd64.whl (78 kB)
                                        78.4/78.4 kB ? eta 0:00:00
Installing collected packages: PyQt5-Qt5, PyQt5-sip, pydot, PyQt5
Successfully installed PyQt5-5.15.9 PyQt5-Qt5-5.15.2 PyQt5-sip-12.11.1 pydot-1.4.2
PS C:\Users\Owner>
```

Graphviz 설치

◆ **Graphviz 설치**

> choco install graphviz

```
PS C:\Users\Owner> choco install graphviz
Chocolatey v1.3.0
Installing the following packages:
graphviz
By installing, you accept licenses for the packages.
Progress: Downloading Graphviz 7.1.0... 100%
```

▪ ▪ ▪ ▪

```
 The install of graphviz was successful.
  Software installed as 'exe', install location is likely default.

Chocolatey installed 1/1 packages.
 See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).
```
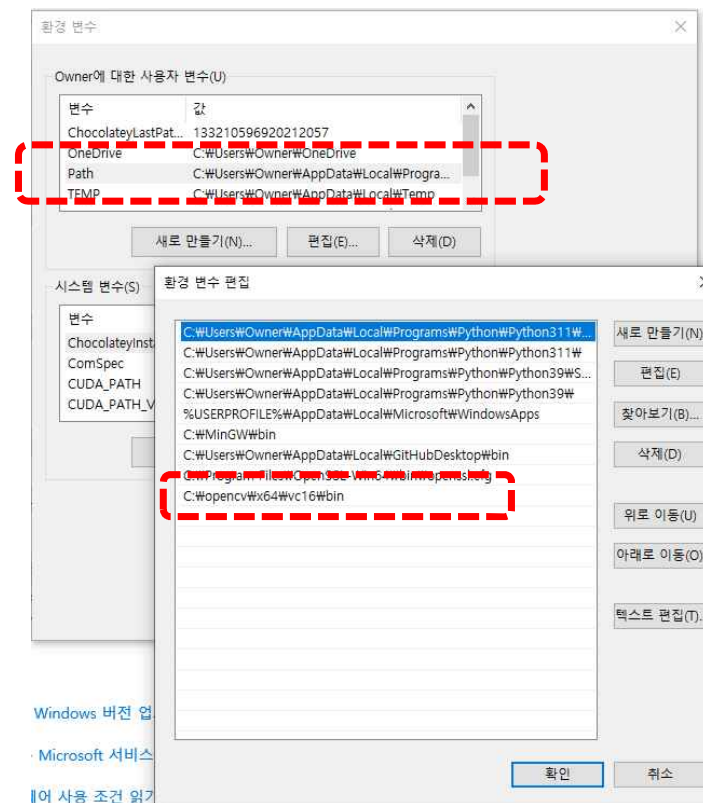
OpenCV 설치

◆ **ROS2와 호환성 검증된 OpenCV 설치**

- https://github.com/ros2/ros2/releases/download/opencv-archives/opencv-3.4.6-vc16.VS2019.zip
- C:\opencv에 설치
- 시스템 PATH에 OpenCV 경로 추가
  C:\opencv\x64\vc16\bin
- Terminal에 OpenCV_DIR 설정
  > setx -m OpenCV_DIR C:\opencv
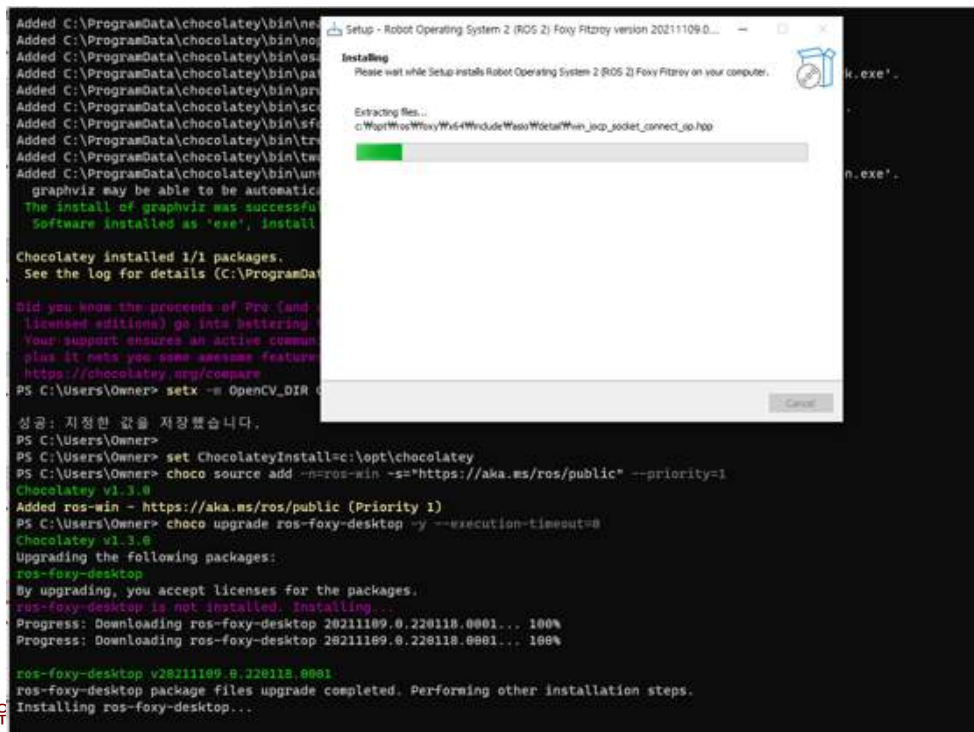
```
PS C:\Users\Owner> setx -m OpenCV_DIR C:\opencv

성공: 지정한 값을 저장했습니다.
PS C:\Users\Owner>
```

ROS2 설치

◆ Terminal에서 ROS2 설치

> set ChocolateyInstall=c:\opt\chocolatey

> choco source add -n=ros-win -s="https://aka.ms/ros/public" --priority=1

> choco upgrade ros-foxy-desktop -y --execution-timeout=0

차세대 네트워
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교수 김 영 탁

ROS2 개발환경 설정