

# Improvement of the hedgehog controller

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One of our robots we have chosen to work with for the PRIA Open® competition is the hedgehog. During our work we realized that the hedgehog controller sometimes has some saving errors. For example, after improving the program, which was just written, the hedgehog controller overwrites the actual program. In this work we want to present different solutions on how to deal with these kinds of and other problems. The simple backup copy, the more advanced backup copy, how to manually generate a \*.pyc file from a \*.py file, the public-keys-procedure and cross-compiling (a method, which works better for C/C++ programming). Each and every solution has its advantages and disadvantages and needs specific circumstances, so that it can work.

## 1. SIMPLE BACKUP COPY

The first solution that probably comes to everybody's minds on how to deal with saving errors is to make a backup copy. Every time before closing the program, all the program has to be copied and inserted into an empty text document. Of course, this way is pretty impractical. That one time the work has been forgotten to be copied, the controller will erase it, or only parts of it, and it will have to be written again. The advantage, if this happens, is that the new program may be better than the last. But, if, for example, more than one programs are being worked on, this way of securing can get confusing and repetitive.

## 2. ADVANCED BACKUP COPY

Especially, if more programs are being worked on, this solution will be easier to work with. Instead of pasting the program on a simple text document, this solution shows how to copy whole files with programs to the hedgehog. First of all, it needs to be made sure there is a FTP-Client-Software installed

on the computer. We are using WinSCP, a free FTP-Client-Software for Windows (the following pictures are based on WinSCP).

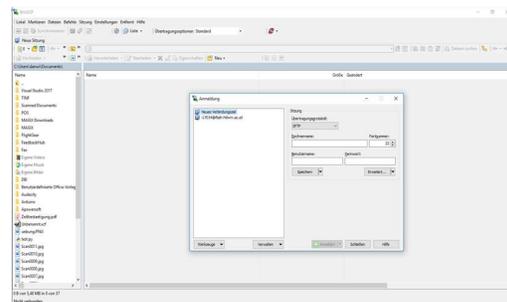


Figure 1 Starting Page WinSCP

After starting the FTP-Client-Software, a connection between the software and the hedgehog has to be developed.

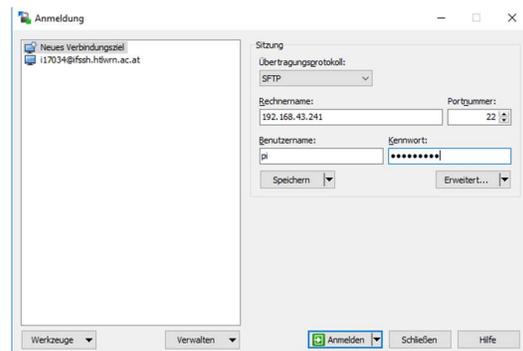


Figure 2 Connecting with hedgehog

(As you may notice in the pictures above, our WinSCP software language is German, but this shall not have any impact on your understanding.) The host name field must be filled with the IP-address of the hedgehog. The user name is “pi” and the associated password is “raspberrry”. Finally, after clicking on the “login” button, a connection with the hedgehog will be built.

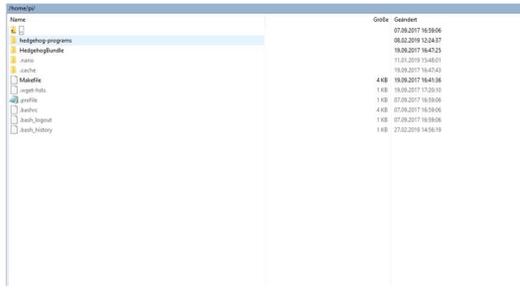


Figure 3 Hedgehog program structure

Afterwards the hedgehog's program structure will be displayed on the desktop. The programs, which were written before on the Web-IDE, will be in the folder "hedgehog-programs".

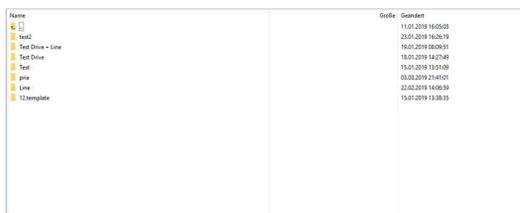


Figure 4 Example: our programs in "hedgehog-programs"

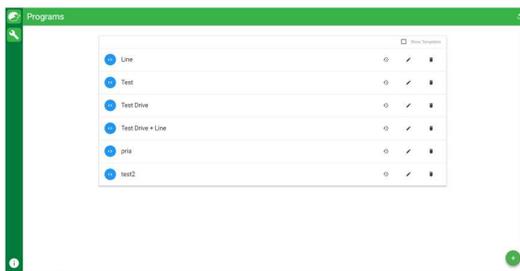


Figure 5 Example: our programs in Web-IDE

Now the programs can be written on the PC and the programs are being copied in the directory.

### 3. MANUALLY GENERATE \*.PYC FILE FROM A \*.PY FILES

If the operating system is Linux, "compileall" can be used, if wished. The following command will go recursively into sub directories and make \*.pyc files for all the python files it finds. The "compileall" module is part of the python standard library, so nothing extra has to be installed for using it. This works the same way for python2 and python3.

`"python -m compileall"`

With the following command a program, which in our case just prints out the number "123", will be copied on the hedgehog.

`"scp program.py pi@ip-address"`



Figure 6 Copy on hedgehog

After inserting it in the hedgehog, the next step is to switch to the hedgehog by typing in the command below.

`"ssh pi@ip-address"`

And the according password, which still is "raspberry".

The following command has to be used to execute the program on the hedgehog:

`"python xxx.pyc"`

(In python3 a subdirectory "\_pycache\_" will be created, where the \*.pyc files can be found and started from.)

### 4. AUTHENTICATION WITH PUBLIC-KEYS

The public-keys-procedure is used for simpler working, since the password does not need to be typed in every time. Asymmetric cryptography (encryption) will be used to authenticate the user. The user has a public key, which can be found in the folder "~/.ssh/authorized\_keys" of the target system. The private key, however, is placed in the "id\_rsa" folder in a directory called "~/.ssh" on the local system. When using the public-key-method to log in on an SSH-server, the server will send a random generated challenge to the client. The server then encrypts the data block with the client's public key. If the client is able to encrypt its cipher with the associated private key, the identity of the user will be confirmed. In the directory "~/.ssh" the key will be created with the following command:

`"ssh-keygen -t rsa -b 4096"`

With a simple click on the "Enter"- button, the name can be left on standard.



Figure 7 Creating the key in the ssh-directory

The following step is to copy the key on the second device, in our case, that is the hedgehog, with the command written below.

„ssh-copy-id -i ~/.ssh/id\_rsa.pub pi@ip-address”

```
danwieser@LAPTOP-SAU0IC0B: ~$ ssh-copy-id -i ~/.ssh/id_rsa.pub pi@192.168.43.241
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: '/home/danwieser/.ssh/id_rsa.pub'
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
pi@192.168.43.241's password:
Number of key(s) added: 1
Now try logging into the machine, with: "ssh 'pi@192.168.43.241'"
and check to make sure that only the key(s) you wanted were added.
```

Figure 8 Command: inserting key on hedgehog

After this connecting with the hedgehog will not need a password anymore. Instead it can be achieved by typing in:

“ssh pi@ip-address”

```
danwieser@LAPTOP-SAU0IC0B: ~$ ssh pi@192.168.43.241
Linux hedgehog 4.9.41-v7+ #1023 SMP Tue Aug 8 16:00:15 BST 2017 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Mon Mar 18 18:33:46 2019 from 192.168.43.146

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.
```

Figure 9 Connection to hedgehog without password

## 5. CROSS COMPILING C/C++

Cross-compiling can be very useful and convenient, if the user is:

- Writing the programs in C or C++
- Working with Linux

According to Wolfgang Dautermann, who is a professor at the FH Joanneum, “a cross-compiler is a compiler, which works on one platform, but creates executables for another platform. All components can differ between the Host-computer and the Target-platform.”

Installing the cross-compiler and the support programs on the local computer will be accomplished by typing:

“sudo apt-get install libc6-armel-cross libc6-dev-armel-cross binutils-arm-linux-gnueabi libcurses5-dev”

```
danwieser@LAPTOP-SAU0IC0B: ~$ sudo apt-get install libc6-armel-cross libc6-dev-armel-cross binutils-arm-linux-gnueabi libcurses5-dev
[sudo] password for danwieser:
```

Figure 10 command installing cross-compiler

in a terminal on Linux. Now the compiler will be installed locally. After writing the program, which needs to be compiled, the command below has to get typed in:

“arm-linux-gnueabi-gcc program\_name.c -o target”

```
danwieser@LAPTOP-SAU0IC0B: ~$ arm-linux-gnueabi-g++ test_.cpp -o t
danwieser@LAPTOP-SAU0IC0B: ~$
```

Figure 11 Command: compiling program in C

This is, if the user is writing the programs in C. If the program language the user is using is C++, the correct program is

“arm-linux-gnueabi-g++ program\_name.cpp -o target”.

```
danwieser@LAPTOP-SAU0IC0B: ~$ scp t pi@192.168.43.241:
pi@192.168.43.241's password:
100% 8936 388.0kB/s 00:00
danwieser@LAPTOP-SAU0IC0B: ~$
```

Figure 12 Command: compiling program in C++

The following command will achieve that the target gets transferred on to the hedgehog:

“scp target pi@ip-address”

```
danwieser@LAPTOP-SAU0IC0B: ~$ scp t pi@192.168.43.241:
pi@192.168.43.241's password:
100% 8936 388.0kB/s 00:00
danwieser@LAPTOP-SAU0IC0B: ~$
```

Figure 13 Command: transferring target to hedgehog

and the password for the raspberry. If this method is combined with public-key authentication, the password, will not be needed. Last but not least, after switching to the hedgehog, the file will be run by typing in:

“./target” (target represents the target, which was set as the file has been compiled.)

```
danwieser@LAPTOP-SAU0IC0B: ~$ ssh pi@192.168.43.241
pi@192.168.43.241's password:
Linux hedgehog 4.9.41-v7+ #1023 SMP Tue Aug 8 16:00:15 BST 2017 armv7l

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the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sat Mar 16 22:31:27 2019 from 192.168.43.146

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@hedgehog:~$ ./t
123
pi@hedgehog:~$
```

Figure 14 Command: running the program

The file itself is on the hedgehog only in machine program available.

```
ELF Header:
  Magic: 7f 45 44 41 44 41 44 41 44 41 44 41 44 41 44 41 44
  Class: ELF32
  Data: Little endian
  Version: 0x1
  OS/ABI: UNIX System V
  ABI Version: 0
  ABI Type: 0
  Processor: 0
  OS/ABI flags: 0
  Type: DYN (Dynamically shared object (shared library))
  Architecture: ARM
  Version string: GNU/Linux
  Entry point address: 00000000
  Start of program headers: 64 (bytes into file)
  Start of section headers: 104 (bytes into file)
  Flags: 0x00000000
  Size of this header: 52 (bytes)
  Section to linker entry point: 0
  Build ID: 192.168.43.241
  URELAZ: 0
  Relocation entries: 0
  Section headers:
  [0] Name: .text
  [1] Name: .init
  [2] Name: .fini
  [3] Name: .plt
  [4] Name: .plt.got
  [5] Name: .got.plt
  [6] Name: .got
  [7] Name: .data
  [8] Name: .bss
  [9] Name: .comment
  [10] Name: .strtab
  [11] Name: .symtab
  [12] Name: .shstrtab
  [13] Name: .dynamic
  [14] Name: .disc
  [15] Name: .eh_frame
  [16] Name: .eh_frame_hdr
  [17] Name: .eh_frame.fde
  [18] Name: .eh_frame.fde.1
  [19] Name: .eh_frame.fde.2
  [20] Name: .eh_frame.fde.3
  [21] Name: .eh_frame.fde.4
  [22] Name: .eh_frame.fde.5
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be made possible and they allow the user to edit the programs comfortably with the desired IDE on the local PC or Laptop. Especially when using public-key authentication, working will become very convenient, as any program can be started from the PC easily with just one command.