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Linux Programming Teaching for Computer Related Majors in the Era of Robotics

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Abstract: *The traditional teaching content of Linux courses for computer majors involves the basic commands, operations, Shell script programming, and network management. However, these teaching contents cannot meet the needs of enterprises and technology in the era of robotics, autonomous driving, and artificial intelligence. In this paper, an improved teaching content is proposed to fit the technique learning of robotics which refers to desktop and embedded system applications development. In addition, some teaching methods and forms are proposed to improve the learning and teaching effectiveness. Through practical teaching verification, the students are attracted to new teaching content and modes. There are significant improvements in learning motivation and mastery of skills.*

Keywords: *Linux OS; Teaching content; Computer; Robotics*

1. Introduction

Linux originates from UNIX, inherits the progressiveness of UNIX from the beginning, and is a real multi task, multi-user, complex kernel operating system (OS). Due to its specific advantages, Linux OS is widely used in the fields of big data, cloud computing, and servers [1]. However, the Linux has been widely applied in the desktop and embedded fields. Based on the teaching content of the Linux programming course in the second semester of the third year of university, students will have a basic understanding of the usage and programming methods of Linux systems. The main content is not focused on server and network management, but on software development applications for desktop operating systems. Consequently, the contents are improved and listed in table1.

Table 1: Teaching Contents Linux Distributions.

Teaching Item	Main Content
Fundamentals of Operating System	Basic knowledge related to operating systems, includes hardware and software
Basic Concept of Linux	The history of Linux OS and the distributions
Basic Commands of Linux	Basic operation of the shell command, includes ls, cd, pwd, help, man, apt install, etc.
Text Edition of Linux	Usage of Vim, Nano, gedit and other text editing tools
Operation of Files and Directories	Usage of commands such as touch, mv, cp, rm, mkdir, rmdir, chown, chmod, ln and others
User and Usergroup	Usage of commands such as useradd, userdel, usermod, su, sudo, history,
Process and Remote Login	Usage of commands such as ps, top, lsof, kill, nice, ssh and others. Details of PID, /proc and VNC, SSH
Shell Script Programming	Regular expression, variables, operators, script execution and control structure
C/C++ Programming in Linux	Usage of compile tools such as gcc, g++ and gdb. The method of code editing and compile.
Make and Makefile Rules	Makefile rules and the coding method of the Makefile document, example analysis of Linux kernel code
Cmake and Cmakelists Rules	Cmakelists rules and the example of project which includes cmakelists document

The previous part pertains to the basic operating methods of Linux systems and the latter part focuses on programming and running methods under Linux systems. Since the course on programming will be

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offered separately, we will not spend too much time on programming methods. Shell script programming is a unique feature of Linux systems, so we will focus on teaching it [2]. The code editing and compilation methods of C/C++programming are the focus of the course, especially the automated code compilation tools for large-scale projects [3,4].

2. Basic Teaching Content Design

2.1. Distributions of Linux Operating System

Due to the characteristics of GNU free software, there are over 50 different Linux distributions in the world [5,6]. Table 2 shows the ten most popular Linux distributions and their official websites. Most distribution versions are actively implemented by volunteers from the open-source community, relying on donations from funds and other forms of support. Some have formed companies and earn profits by providing technical support to other companies. However, these distributions are all based on the same kernel modification implementation [7].

Table 2: Partial Classical Cases of Linux Distributions.

Distribution	Website
RHEL/Red Hat	https://www.redhat.com/
CentOS	https://www.centos.org/
Debian	https://www.debian.org/
Ubuntu	https://ubuntu.com/
Fedora	https://fedoraproject.org/
Arch Linux	https://archlinux.org/
SUSE	https://www.suse.com/
Linux Mint	https://www.linuxmint.com/
Gentoo	https://www.gentoo.org/
Kali Linux	http://www.kali.org/

In China, there are several domestic open-source operating systems which is modified based on the Linux kernel codes. Table 3 shows the famous six distributions which are used in areas with high demands for network and information security.

Table 3: Partial Cases of Linux Distributions in China.

Distribution	Website
Kylin	https://www.kylinos.cn
RedFlag	https://www.chinaredflag.cn
Deepin	https://www.deepin.org/index/zh
UbuntuKylin	https://www.ubuntukylin.com/
StartOS	https://www.startos.com/

Due to the widespread application of Ubuntu distribution, especially in the desktop level application development, the whole teaching contents are based on Ubuntu Linux OS [8].

2.2. Linux Operating System Installation

Due to the user-friendly graphical interface and simple usability of Windows, most laptops or desktop computers default to installing the Windows operating system. Therefore, the first thing to consider when learning Linux is how to install a distribution version of Linux. There are four commonly used installation methods shown in table 4. For professional programming techniques in desktop application development, Linux operating system is usually installed on bare metal device or physical machine. The advantage of this installation method is that it does not require additional system switching. For users whose host operating system is Windows, it is necessary to install a third-party software to simulate physical machine functionality, and then install the Linux operating system in the virtual software. The most popular method is to use virtual machine software, such as VirtualBox and VMware [9]. Among them, VirtualBox is free of charge and VMware also has free version. For Windows users, Windows 10 and later versions have a novel feature which is WSL, namely, the Windows Subsystem for Linux [10].

If users only want to experience and learn Shell commands and script programming methods, they do not need to install the Linux operating system. Tools like online shell environments can simulate the desired functionality.

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Table 4: Partial Cases of Linux Distributions in China.

Installation Carrier	Description
Physical Machine	Media installation required, such as USB disk
Virtual Machine	Oracle VirtualBox https://www.virtualbox.org/ VMware https://www.vmware.com/
WSL	Windows Subsystem for Linux
Others (Online shell)	https://www.tutorialspoint.com/unix_terminal_online.php https://www.jyshare.com/compile/18/

2.3. Basic Commands of Linux

Due to the frequent exposure of students to the Windows system in their daily lives, they are accustomed to the mouse click window operation interface and feel unfamiliar with the terminal command line interaction mode of Linux. Table 5 lists the commonly used commands of Linux OS.

Table 5: MOOC course resources in China.

Categories	Commands
File operation	arj, basename, bzip2, chgrp, chmod, chown, cat, cut, cmp, col, cpio, compress, dd, diff, dump, emacs, ed, ex, sort, touch, tail, tee, tar, find, file, gzip, grep, head, ln, less, mv, more, od, sed, unzip, wc, wc, zip
Directory operation	cd, cp, dirname, dirs, ls, mkdir, pwd, pushd, popd, rm, rmdir
Shell operation	alias, bg, bind, builtin, command, declare, echo, env, exit, export, enable, exec, fg, fc, help, logout, read, set, type, unset, umask, unalias
System management operation	batch, chpasswd, crontab, hroot, depmod, free, groupadd, groupdel, gpasswd, groupmod, halt, init, ipcs, killall, lsmod, last, logsave, logwatch, mpstat, newusers, nologin, nice, ps, pstree, reboot, su, sudo, top, time, uname, watch, runlevel, poweroff
Print operation	accept, cancel, cupsdisable, cupsenable, dmesg, lp, lpr, lpc, lpq, lpadmin, reject
File System Management	At, atq, qtrm, chattr, dumpe2fs, e2image, edquota, fsck, findfs, lsattr, mount, mkfs, mke2fs, quotaoff, quotacheck, mountpoint, stat, service, sysctl, sync
Software package management	apt-get, apt, aptitude, apt-key, apt-sortpkgs, chkconfig, dpkg, dpkg-deb, dpkg-divert, dpkg-query, rpmdb, rpmquery, rpmsign, yum, snap
Network management	arp, arping, ping, ipconfig, arpwatch, arpd, arptables, ab, apachectl, dhclient, dig, elinks, elm, exportfs, ftp, ftpcount, ftpshut, ftptop, ftpwho, hostname, host, httpd, htpasswd, htdigest, ifcfg, ifdown, ifup, ipcale, iptables, ip, iptraf, mail, netstat, nmap, route, rsh, ssh, scp, sftp, tftp, telnet, wget
Programming development	as, expr, gcc, gdb, gcov, ld, ldd, make, cmake, mktemp, nm, perl, php, protoize, test, python, lua
Hardware operation	badblocks, bolockdev, df, eject, fdisk, grub, hwclock, hdparm, lsusb, lspci, lilo, lvcreate, pvscan, pvdisplay, pvremove, pvck, pvchange, septic, systool, volname, lvscan, mkfs, mkinitrd, mknod, mkswap
Practical tools	bc, cksum, cal, clear, date, info, login, man, md5sum, sum, sleep, stty, sln, talk, whatis, who, whoami, wall

3. Extended Content for Robotics and Autonoumous Driving

With the continuous popularity of artificial intelligence research, applying it to specific scenarios is the future trend. A typical application is robotic which simulate human or animal intelligence and serve

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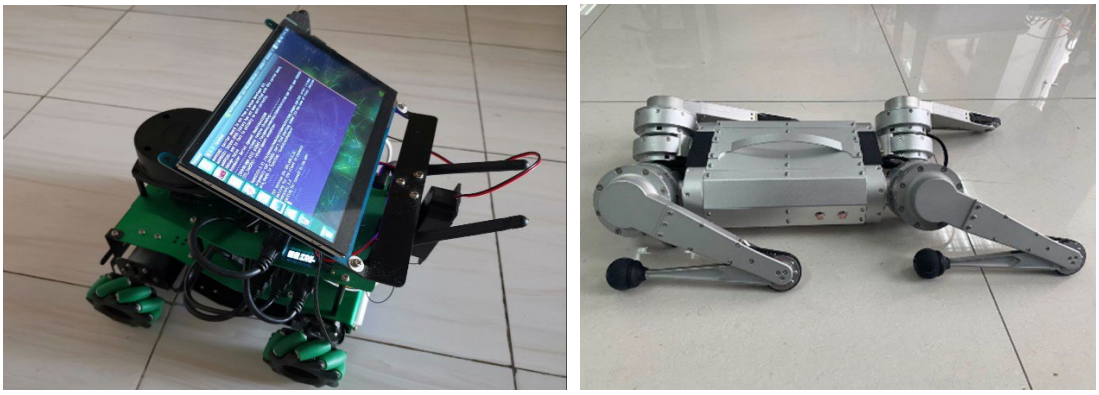
humans. In recent years, mobile robots and robodogs have entered the commercial stage, especially hotel delivery robots, guide robots, factory warehousing robots, guide robots, etc. Autonomous driving can be seen as an outdoor version of mobile robot which needs more sensors and much more intelligence to perceive the surrounding environment. Both of them need Linux OS to manage the hardware resources and the fundamental software.

3.1. Linux Application in Robotics

Due to the fact that most of the previous robot operating systems (ROS) were based on Ubuntu Linux, the Linux OS is gradually popular in robot applications. In fact, the ROS is not an OS, but a fundamental software which provides communication mechanism for various basic modules [11]. Most academic or commercial robots are using ROS in the worldwide, namely, there are based on Linux OS. Figure 1(a) is an indoor mobile robot platform which is used for learning purpose. Figure 1(b) shows another popular robot which is the robodog or mechanical dog [12,13].

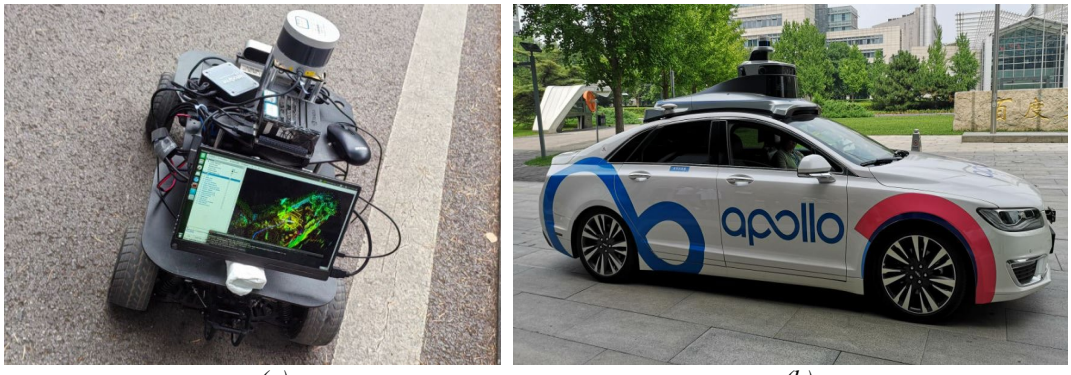


(a) *(b)*

Figure 1: Robotics using Linux. (a) Mobile robot for studies. (b) Mechanical dog.

3.2. Linux Application in Autonomous Driving

In the outdoor environment, the mobile robots usually need more abundant sensors to achieve more information of the surroundings compared with indoor robots. Figure 2(a) shows a mobile robot in the outdoor environment with a 3D laser LiDAR sensor. The OS is ubuntu distribution of Linux which is not much different from the indoor version. Figure 2(b) is an autonomous driving car which can be thought of as an improved version of mobile robot. The driverless car is from Baidu Inc. and is based on the Apollo software [14]. It is worth noting that the Apollo is installed on ubuntu Linux OS.



(a) *(b)*

Figure 2: Autonomous driving using Linux. (a) Outdoor mobile robot. (b) Driverless car.

Based on the above facts, the Linux course in Computer Science and Technology major should be aligned with frontier technology knowledge. In addition to learning basic commands, it should involve programming languages such as Shell, Python, C/C++, and introduce mobile robots into the classroom to attract students' interest in learning.

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4. Course Resources

Different from traditional teaching modes, students can access various learning resources online through various channels in the era of artificial intelligence and internet information explosion. Those applied knowledge require students to practice hands-on, rather than just listening like learning humanities or science knowledge. For those who want to learn some extended application knowledge, official online resources such as MOOC are very good resources. As of May 2024, there are 19 Linux related courses are uploaded to online website https://www.icourse163.org. Among them, five courses are rated as a National Excellent Course [15]. Table 6 shows the course names and related information that different schools or majors have different teaching contents and focuses.

Table 6: MOOC course resources in China.

Course Name	University	National Premium Course
Linux operating system programming	University of Electronic Science and technology	Yes
Linux network operating system	Xuchang Vocational and Technical College	Yes
Linux operating system	Zhejiang Industry & Trade Vocational College	No
Linux basics	Changzhou College of Information Technology	No
Linux system management	Ningbo City College of Vocational Technology	Yes
Linux server configuration and management	Chongqing Vocational Institute of Engineering	Yes
Linux operating system	Suzhou Institute of Trade&Commerce	No
Linux programming technology	Xi'an University of Posts & Telecommunications	No
Operating system and Linux kernel	Xi'an University of Posts & Telecommunications	No
Linux system applications	Nanjing Vocational College of Information Technology	No
Linux system applications	Zhongyuan University of Technology	No
Fundamentals of Linux Operating System	Jiangsu vocational college of electronics and information	No
Linux network operating system	Jiangsu College of Finance & Accounting	No
Embedded Linux Application and Development Practice	Jiangsu Vocational College of Information Technology	Yes
Linux network management	Sichuan Vocational College of Information Technology	No
Operating System Principles and Linux Practice	Zhejiang University of Science and Technology	No
Linux system configuration and management	Chongqing College of Electronic Engineering	No
Learn Linux operating system from scratch	Changzhou University	No
Linux Application Programming Technology	Jinling Institute of Technology	No

In addition to these official learning resource websites, some video websites and technical forums can also serve as channels for learning, such as bilibili and CSDN [16,17].

5. Conclusion

In the era of artificial intelligence robotics, the Linux programming course for computer related majors should to keep up with the times. Different from the skill requirements of network engineering or data operation and maintenance majors, desktop level or embedded Linux program development should

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be a priority. Introducing teaching equipment such as mobile robots will be a trend in future course teaching [18]. In addition, the teaching evaluation focuses more on students' mastery of knowledge rather than their ability to take exams.

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