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Exploration of LabVIEW Teaching Mode under the Background of Engineering Application

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Abstract

Cultivating engineering practice thinking and enhancing engineering practice ability are core issues in the process of applied undergraduate teaching. This paper analyzes the inherent advantages of the LabVIEW graphical programming language in engineering applications and the main reasons why the current teaching model cannot achieve the training goals. It proposes a LabVIEW teaching model based on the thinking of engineering practice. Combined with the characteristics of the LabVIEW language, this paper introduces in detail the teaching practice of LabVIEW under the thinking of engineering practice from aspects such as teaching content arrangement, teaching method selection, teaching practice setting, and teaching evaluation system construction. The teaching effectiveness of several years has proven the effectiveness of this teaching model, and the students' engineering application ability and engineering thinking ability have been greatly improved.

Subject Areas

Mechanical Engineering

Keywords

Teaching Reform LabVIEW, Engineering Application Background, Teaching Mode

1. Introduction

Tertiary science and engineering education plays a significant role in cultivating a large number of scientific and technological talents for our country's economic development and social progress, which has increasingly high demands on students' innovative abilities and professional practical capabilities. Therefore, based on the educational goals of cultivating compound talents with high quality, universities must have the environment and conditions to promote quality education and cultivate compound talents. Only by constructing a comprehensive innovation engineering training base mainly for students of science and engineering can we truly provide students with an environment of large-scale engineering. Innovative engineering design and training can be arranged for students in various types of innovative practices to cultivate the innovative practical abilities of university students and implement quality education.

Engineering practice aims to achieve certain objective entities and has characteristics such as comprehensiveness. The engineering practice ability of students, in a narrow sense, can be deconstructed as the ability to apply professional knowledge and technology to solve engineering problems under the background of professional disciplines, focusing on problem-solving at the technical level. Broadly speaking, engineering practice ability can be deconstructed as the set of abilities required for students to engage in professional practice as quasi-engineers in real practical situations, not only focusing on solving professional problems at the technical level but also focusing on interacting with stakeholders at the non-technical level [1]. Based on the characteristics of engineering practice and the decomposition of engineering practice ability, engineering practice thinking is a comprehensive thinking [2], such as balance and compromise, simplification and optimization, structured thinking, and abstract thinking in practice, which can guide the engineering practice activities of engineers.

A series of "combination punches" for deepening the integration of education and industry introduced the aim to build a model of education and industry integration, positive interaction, and collaborative education, and to improve the construction level of applied undergraduate colleges and universities [3] [4]. Therefore, under the guidance of engineering thinking, it is necessary to explore and reconstruct the teaching model according to the feasibility, gradualness, levelness, systematicness, and evaluability of engineering practice ability [5]-[8].

LabVIEW is also a general programming system. LabVIEW is a graphical programming language oriented to engineers, using a program block diagram (Block Diagram) programming method that fits the thinking habits of engineers and the engineering thinking. LabVIEW has the following characteristics: 1) The syntax is simple, intuitive, and easy to learn, with built-in common data structures and corresponding I/O controls; 2) The programming process, that is, the drawing process of the program block diagram, fits the engineering practice thinking mode, what you think is what you get; 3) The program structure and programming mode of LabVIEW have been tested by long-term engineering practice and have efficiency, feasibility, and economy. LabVIEW also supports object-oriented programming, which improves the code reuse rate and facilitates project division of labor and cooperation; 4) There is a rich extended tool library or third-party tool library, and functions in the library can achieve database operations, time-frequency analysis, image processing, and other functions. LabVIEW and its technical ecological chain have bridged the gap between software and hardware, so it has been widely used in engineering fields such as data acquisition, electronic testing, instrumentation, and automatic control. These characteristics show the relative advantages of LabVIEW in shaping engineering thinking and engineering practice.

In the conventional teaching model similar to the C language, too much emphasis on the mastery of syntax and rules will inevitably dilute the advantages of LabVIEW's engineering, which is not conducive to the cultivation of engineering practice thinking ability, resulting in a simplified and homogenized learning process. Students only learn basic syntax and simple processes, but they do not know or dare to apply them to practice. Therefore, many colleges and universities have carried out engineering practice curriculum reforms by combining and utilizing the characteristics of LabVIEW, focusing on the cultivation of engineering practice thinking, and have provided good solutions in terms of specific project selection, experimental practice design, application expansion, innovation and entrepreneurship guidance, and assessment methods.

LabVIEW fits the thinking habits of engineers, has a low threshold for engineering practice, and is easy to cultivate engineering thinking literacy. This paper summarizes the teaching work in recent years and systematically provides an overall plan for the reform of LabVIEW curriculum teaching under the guidance of engineering practice thinking. From the aspects of technical ecology, professional background, school characteristics, and talent demand, practice projects are selected on purpose, and teaching content is set around projects, teaching methods and means are designed, in-class and out-of-class practice is set, and a comprehensive evaluation system is established. At the same time, key issues that arise in the practice process are discussed with corresponding solutions, hoping to play a certain reference role in the teaching reform of various majors in electronic information disciplines.

2. Problems in the LabVIEW Teaching Model and Conditions

In the past teaching, the teaching model of C language was followed, which could not reflect engineering thinking, nor could it meet the needs of industry-education integration and the development of applied undergraduates [9] [10]. The main reasons are as follows:

1) The teaching content cannot reflect engineering thinking. Compared with C language, LabVIEW has a low learning threshold, is easy to start, and has rich front panel controls, function libraries, and program structures that make it easier to build engineering applications. However, in the teaching process, the teaching model of C language courses is still adopted, focusing on data types, program structures, functions, and files, etc., programming syntax and elements.

2) The teaching method cannot reflect engineering practice thinking. In terms of teaching methods, static PPT is used, and the classroom is mainly used for lectures, such as knowledge point explanations, example explanations, etc. During the learning period, students passively accept and cannot think actively, nor can

they exert their subjective initiative. The block diagram programming environment of LabVIEW is more suitable for analyzing, analyzing, and drawing (programming) according to engineering thinking, allowing students to feel the process of analyzing and solving problems under engineering thinking.

3) The teaching practice setting is single. There are 8 class hours of computer experiments arranged in the class, and the experimental content is only separate experiments or simple practices within the independent teaching unit, lacking the connection and connection between knowledge; the practice content is mostly abstract syntax training, mathematical algorithms, or program logic design that is divorced from the engineering background, ignoring the thinking training in solving actual problems, and it is impossible to measure the students' ability to analyze and solve problems. The practice class is selected by the students, among which the algorithm structure accounts for 30%, and the mastery of algorithm logic and program structure is inspected. The comprehensive practice question accounts for 70%, and the rationality and integrity of the system design are inspected. However, the implementation effect is not ideal, and there are phenomena such as simple topics, detachment from reality, and rush to complete. It is impossible to objectively judge the students' ability to comprehensively use LabVIEW to solve practical engineering problems, and it is impossible to achieve the essential improvement of teaching effectiveness.

4) The teaching evaluation method is single. The paper-based test examines the basic concepts, accounting for 30% - 40%, and 5 - 8 independent programs inspect the basic programming logic and the use of programming elements, accounting for 60% - 70%. However, the practice course can only reflect the students' mastery of the LabVIEW language and cannot reflect their engineering practice thinking and problem-solving abilities.

3. LabVIEW Teaching Model under Engineering Practice Thinking

Designing the LabVIEW teaching model with an engineering mindset involves introducing projects and engineering to help students logically understand the process of problem discovery, analysis, and solution in engineering thinking based on their study of the LabVIEW language. Prioritize engineering contexts, followed by programming elements, then experimental and practical verification, and finally expand ideas [11]-[15]. The teaching model is designed with machine vision inspection as the engineering context, as shown in **Figure 1**.

1) Solicit engineering backgrounds and application scenarios. Before the course begins, the course team teachers lead discussions with student participation on the engineering applications of LabVIEW. The engineering application background and scenarios of the course are discussed from several aspects such as technical ecology, professional background, school characteristics, and talent demand. The main engineering background of the course is selected based on the teaching staff's capabilities and students' interests.

2) Develop teaching content and various teaching segments. Taking "LabVIEW Machine Vision Geometric Measurement Application" as an example, the teaching content, unit division, and practical segments are set up in a progressive manner. The teaching content is divided into five core tasks: LabVIEW language basics, machine vision basics, image and video acquisition, image and vision functions, and geometric measurement. The basic part includes the necessary programming elements and background knowledge for solving such engineering problems. Teachers focus on explaining and encouraging students to reinforce their learning after class. The remaining three tasks are taught in a layered manner in class, focusing on problem discovery, analysis, and solution.

3) Conduct extracurricular extension practice activities. Organize engineering extension practices after class to exercise students' abilities to solve engineering problems, thereby deeply verifying classroom teaching content and enabling them to draw inferences. At the same time, discuss the integration of new technologies, new equipment, and LabVIEW to further expand students' horizons.

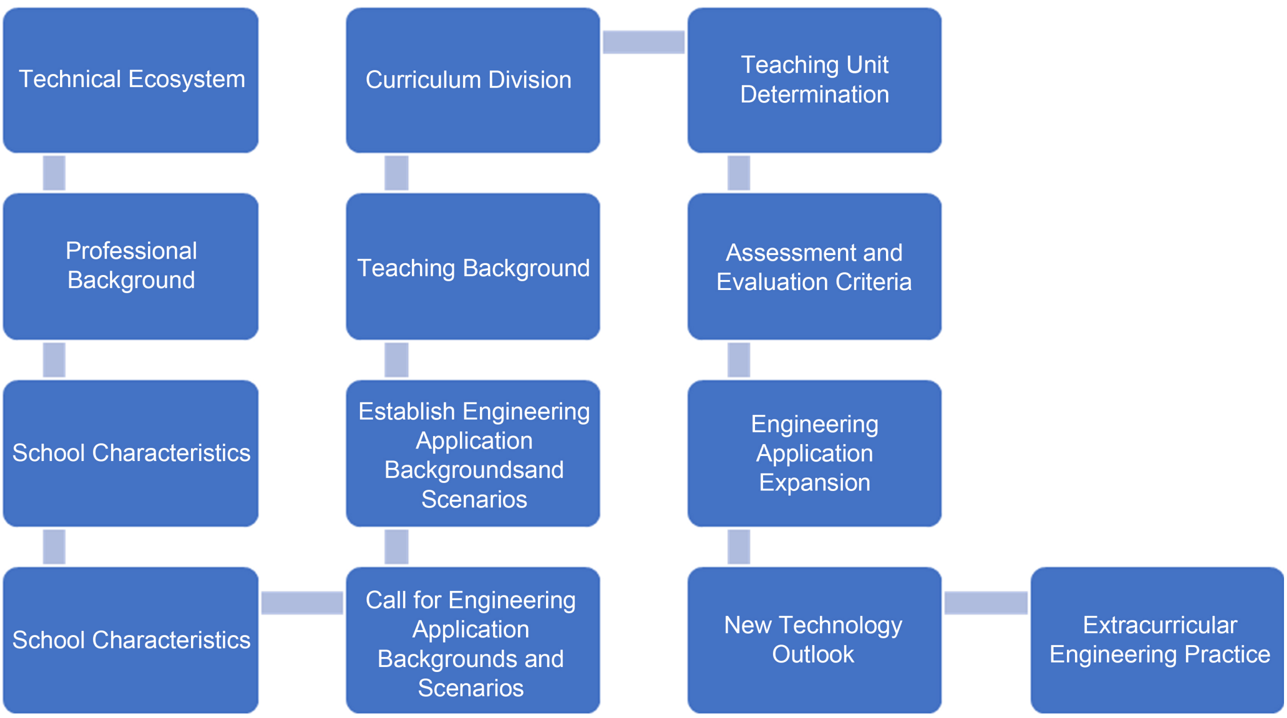

Figure 1. Teaching system under the thinking of engineering practice.

4. LabVIEW Machine Vision Teaching Design

4.1. Selection of Teaching Content

The LabVIEW teaching content system includes three parts: programming basics, engineering applications, and extended engineering applications, as shown in Figure 2. The programming basics refer to the LabVIEW programming syntax and some special programming elements and concepts that are different from text languages. The graphical LabVIEW programming is visual and intuitive, making it easy to get started. Students with a foundation in C language can easily grasp it under the real-time demonstration of teachers. This part can minimize classroom teaching and adopt self-study, MOOCs, and other methods.

The teaching content of the engineering application part includes signals, communications, vision, and third-party libraries. This part reflects the depth and breadth of LabVIEW's engineering applications and its advantages in engineering scenarios. It should be the focus of classroom teaching. In addition, different LabVIEW program architectures and programming patterns are often used in actual engineering applications to face different engineering applications. The appropriate architecture and pattern can organize the program reasonably and reduce logical and timing errors.

Extended engineering practice introduces the application and positioning of LabVIEW technology and its technical ecology in the industrial environment through practical cases. It introduces the integration of LabVIEW with other technologies, such as the integration with Python, deep learning technology, etc. By analyzing the solution of practical problems by the LabVIEW technical ecology, it further enhances students' abilities to solve engineering problems and strengthens their motivation to learn the course.

The LabVIEW technical ecology chain is relatively long, and the engineering applications are also closely related to other courses. After students have completed the study and training of the machine vision course, supplemented by the knowledge of other theoretical and practical courses, they can completely use the LabVIEW technical ecology to solve other engineering problems under the thinking of engineering practice.

In specific teaching, the focus should be placed on cultivating students' abilities to use engineering thinking to discover, analyze, and solve problems. To this end, teaching practice can be divided into two stages: in-class practice and extracurricular comprehensive practice. In-class practice includes LabVIEW syntax and programming practice, engineering project guidance practice, and extracurricular extendable practice. Extracurricular comprehensive practice includes project-guided comprehensive practice and extracurricular engineering extendable comprehensive practice. LabVIEW syntax and programming practice are used to consolidate the basic content of classroom teaching, master syntax, program structure, and programming patterns, and provide programming ability support for subsequent engineering practice. In the extracurricular comprehensive practice tasks, the technical solutions involved in the in-class practice are followed up, and their engineering application background and scenarios are strengthened to solve the problems proposed at the beginning of the course, enhance students' ability to apply what they have learned, and inspect and improve teaching effectiveness.

4.2. Formulation of Teaching Methods

Under the background of engineering applications, the traditional teaching model led by teachers and passive students often makes the teaching content divorced from reality and lacks direction, which cannot arouse students' enthusiasm and initiative for learning. The teaching method with engineering practice thinking is shown in **Figure 2**, highlighting the concept of engineering applications or engineering projects as the core. The application background and scenarios of the project are determined by teachers and students together, with students raising more questions and teachers interpreting and expanding the background. Teachers provide analysis and suggestions for the solution ideas and plans, and students provide their own plans. Technical support and specific program content are student-centered, and students learn and complete them under the guidance of teachers. The whole process highlights the engineering background, with students participating in the entire process of problem-raising, analysis, and solution driven by interest, and teachers grasping the difficulties and direction for directional guidance.

To successfully implement the above teaching methods, various teaching methods should be flexibly applied in the specific teaching process according to the feedback of the students' situation and the characteristics of the teaching content. To establish the engineering application background and scenarios, collect the engineering application background and scenarios, divide the teaching content, determine the teaching units, and set the assessment and evaluation standards.

The programming foundation section includes the basic syntax and concepts of the LabVIEW language, data structures, program structures, data I/O, and other content. This part is relatively simple and intuitive, and adopts a teaching method that emphasizes teacher-student interaction with students as the main body. A project-driven approach is used where teachers demonstrate the specific program writing process. Students write programs simultaneously, can raise questions at any time, and discuss and solve problems. The types of vision functions are numerous, the meanings of parameters are profound, and the usage scenarios and parameter settings require detailed guidance from teachers, along with case demonstrations. The programming patterns for vision applications are also more complicated and not intuitive, requiring some understanding of software engineering concepts, and also requiring students to have a broader perspective. Students are relatively unfamiliar with this part of the content and have a certain fear of difficulty, so it is necessary to play the guiding role of teachers. The programming patterns have fixed program logic and architecture. In the course, teaching methods such as engineering background introduction, case analysis, teacher-student interaction, and some engineering practice are adopted, so that students can basically master it.

Expanding engineering practice primarily involves applying LabVIEW and its technical ecosystem to solve real-world problems. This is generally done through a project-driven approach, with a teaching method that emphasizes student-led learning, group collaboration and discussion, and teacher-directed guidance. During the implementation of these teaching methods, it is also necessary to monitor student progress in real-time, make timely adjustments and corrections to issues that arise during the teaching process, and form a positive feedback loop system.

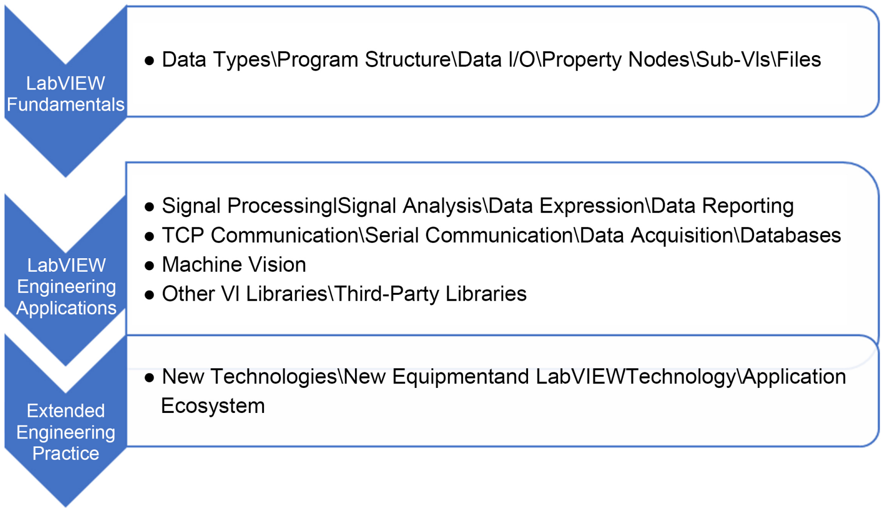

Figure 2. Teaching method with engineering application as the core.

4.3. Construction of Teaching Evaluation System

The traditional "class participation + final exam" model focuses only on the examination of knowledge points and cannot achieve an assessment of capabilities at the level of engineering practice. Under the engineering practice mindset, the LabVIEW teaching evaluation system should accurately assess students' abilities to use LabVIEW to solve real-world problems, as well as the actual teaching effectiveness of teachers. The teaching model evaluation system under the engineering practice mindset takes the mastery of knowledge points as the basis for examination, and focuses on the resolution and effectiveness of engineering problems in teaching practice, thereby shifting the teaching evaluation from knowledge examination to capability examination. The specific evaluation system is shown in Table 1.

Table 1. Teaching evaluation.

Number	Evaluation Project	Evaluation Metrics
1	Final Exam 20%	Theoretical Concept Knowledge Basic Knowledgetest 40%
2	Teaching Process 30%	Engineering Application 40% Engineering Extension 20% Course Practice 30%
3	Course Practice 30%	Quality of Completion 60% Defense Session 40%
4	Extracurricular Practice 20%	Extracurricular Practice 20% Quality of Completion 60% Defense Session 40%

In Table 1, the final exam reflects students' grasp of the basic theories, concepts, and knowledge points of the course. The teaching process evaluates students' practical hands-on abilities under the guidance of teachers, the course practice evaluates students' problem-solving abilities, and extracurricular practice evaluates students' systematic engineering practice capabilities.

5. Teaching Implementation Process and Effectiveness

The teaching reform is implemented with the Electronic Information Science and Technology major as the subject. The LabVIEW Basic Programming course consists of 32 class hours and includes 4 weeks of concentrated practice. The LabVIEW System Design and Engineering Application course has 32 class hours, with 24 hours dedicated to theoretical instruction and 8 hours to practice. The courses are guided by engineering project backgrounds and are centered on student-centric and student-led teaching approaches during the instructional process.

Taking the "LabVIEW Machine Vision Geometric Measurement Application" engineering task as an example, students learn the basic content of LabVIEW and visual programming by combining video resources, MOOCs, and other online teaching resources. They list the necessary programming concepts, functions, and other essential elements for the project, then demonstrate and explain through program block diagrams, with the teacher providing comments and summary at the end. In this process, the basic programming part of LabVIEW and visual functions adopts a task-driven approach, supplemented by extracurricular practice assignments. The teacher assigns tasks in advance and explains them, with students completing the tasks in groups and discussing their experiences and lessons learned.

The sections on image acquisition, visual processing, and programming patterns are the focus and difficulty points, with 12 hours of theory and 4 hours of lab classes. These are conducted in an interactive manner between teachers and students, supplemented by situational case studies. The teacher analyzes and demonstrates image acquisition modes, LabVIEW programming patterns, and program architectures, explaining the use cases for different modes and frameworks, inspiring and guiding students in practice and verification.

The extracurricular practice emphasizes the LabVIEW technical ecosystem and the integration of LabVIEW with other technology platforms. The class schedule is flexibly set according to feedback from students. This part uses a combination of teacher explanations and case introductions, with engineering tasks driving the teaching, highlighting the role of extracurricular practice, expanding students' engineering horizons, and enhancing their practical engineering capabilities.

Through the attempt, establishment, and experimentation of the teaching model under the aforementioned engineering thinking, students' enthusiasm for learning has significantly increased, classroom activity has been improved, and comprehensive abilities have been greatly enhanced. The achievement rate of the training goal of mastering the basic syntax and program structure of LabVIEW is

86%; the achievement rate of using the LabVIEW system to solve general engineering problems is 80%, and some students still need to further strengthen their problem analysis and practical abilities. The results of extracurricular practice have shown that through team collaboration and teacher guidance, students can solve more complex engineering problems. Some of the results are shown in Table 2 and Figure 3. The student achievements listed in Figure 3 include NI vision camera acquisition and onnx inference interface.

Table 2. Extracurricular practice achievements.

Number	Achievement Name	Achievement Category
1	Position Sensing and Trajectory Tracking	Graduation Project
2	Point-by-Point Digital Filtering Experiment Design	Scientific Pape
3	Grain Appearance Quality Inspection	Major Innovation Project
4	Two-Dimensional Detection System	Graduation Project
5	Material Deformation Measurement System	Graduation Project
6	Glass Defect Detection System	Major Innovation Project
7	Visual Guidance Transfer System	Enterprise Cooperation
8	Automatic Generation and Implementation of Parking Path	Graduation Project
9	Automatic Sorting of Sheet Materials	Major Innovation Project

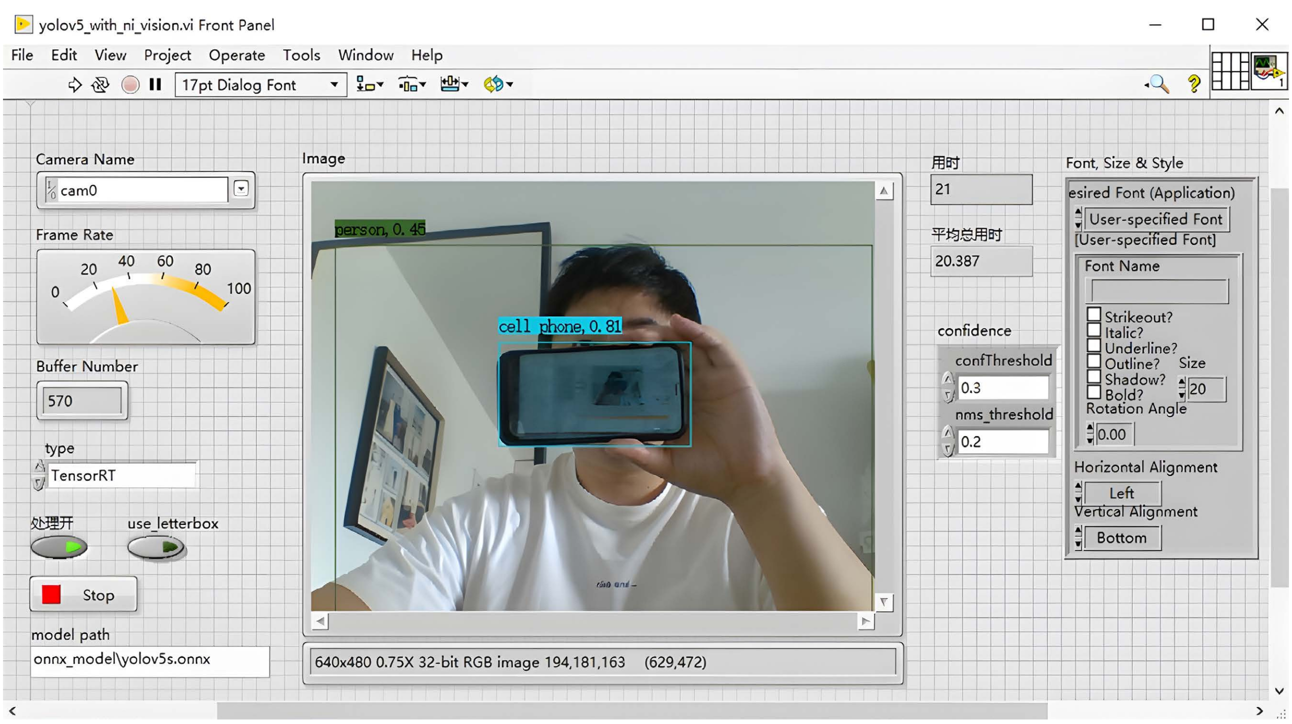

Figure 3. NI vision camera acquisition and onnx inference interface.

5. Conclusion

In applied undergraduate education, adopting an engineering practice mindset can achieve the integration of theory and practice, allowing students to guide practice and apply what they have learned under an engineering mindset. By integrating the characteristics of LabVIEW and its technical ecosystem in engineering applications, the reform and practice of this course's teaching model have enhanced the achievement of training objectives, enabling students to truly possess certain practical engineering capabilities. However, due to the strong comprehensiveness of engineering practice and the lengthy knowledge-technology chain, a teaching model that is entirely project-based may be detrimental to students' systematic and complete learning of knowledge, and it also places high demands on the engineering practice background of teachers. Therefore, in the later stages of teaching, it is necessary to carefully select projects, categorize them according to difficulty, comprehensiveness, and relevance to other courses, teach students according to their abilities based on the project's difficulty, and provide reasonable evaluations according to the different contributions of students within the project groups.

Conflicts of Interest

The author declares no conflicts of interest.

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