

# Course Introduction

## Week 1

Yulei Sui

School of Computer Science and Engineering

University of New South Wales, Australia

# COMP6131 Inaugural Offering at UNSW

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- Give me some courses that you think are related.
  - System and Software Security Assessment (COMP6447)
  - Security Engineering and Cyber Security (COMP6441/COMP6841)
  - Programming Languages and Compilers (COMP3131/COMP9102)
  - Advanced C++ Programming (COMP6771)
  - Algorithmic Verification (COMP3153/COMP9153)

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  - Algorithmic Verification (COMP3153/COMP9153)

Your active participation in and off-class discussions, as well as your feedback, will be invaluable. Hope to make your learning experience an enjoyable and rewarding one.

# Administration

- Course convenor and lecturer: A/Prof. Yulei Sui
- Email: [cs6131@cse.unsw.edu.au](mailto:cs6131@cse.unsw.edu.au)
- Course webpage: <https://webcms3.cse.unsw.edu.au/COMP6131/24T2>
- Course ED forums: <https://edstem.org/au/join/7tPnP2>
- Important messages will be announced on the course homepage, and urgent messages will also be sent to you via email.
- Course admin:
  - Xiao Cheng ([xiao.cheng@unsw.edu.au](mailto:xiao.cheng@unsw.edu.au))
- Lab Demonstrator:
  - Kaiqi Liang ([kaiqi.liang@unsw.edu.au](mailto:kaiqi.liang@unsw.edu.au))
- Course keywords: Source Code Analysis, Security vulnerabilities, Verification, Abstract Interpretation



# Lectures and Labs

- Lecture
  - Time: 11:00 - 13:00, Friday
  - Location: Old Main Building **G31 (K-K15-G31)**
- Lab
  - Time: 13:00 - 15:00, Friday
  - Location: Old Main Building **G32 (K-K15-G32)**
- Consultation (appointment is preferred)
  - Time: 15:00 - 16:00, Friday
  - Location: 501H, K17

# Course Aim

In this course, you will learn to create **automated code analysis and verification tools** using a **modern compiler** and an **open-source** static analysis framework, to perform **code comprehension**, **vulnerability detection** and code **verification** in real-world software systems.

# Teaching Strategy and Rationale

This course has three major components:

- **Lectures** (10 weeks excluding Week 6 for study break)
- **Labs** (10 weeks excluding Week 6 for study break)
- **Assignments** (Assignments 1-3)

This is a project-based course and you are expected to produce a tool towards the end of the course and **NO paper examination** is required!

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Assessment Type	Name	Percentage %
Lab work	Quiz-1 & Exercise-1	10%
	Quiz-2 & Exercise-3	10%
	Quiz-3 & Exercise-3	10%
Assignment-1	Information flow tracking	20%
Assignment-2	Symbolic execution	25%
Assignment-3	Abstract interpretation	25%

# Lectures

Course contents:

- Foundational **theories of static code analysis and verification** aimed at detecting bugs and verifying the absence of bugs.
- Some practical **demonstrations of examples and coding**
- **Problem-solving skills** (algorithms, testing, debugging)
- Lecture slides typically available before each lecture. Lectures are recorded.

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Get the most out of COMP6131:

- **Attend the lectures/labs and get involved!** Ask questions in class and on Ed forums (no pasting code solutions allowed).
- **Be open-minded.** While you will use C++ to implement your code checker for analyzing C programs in this course. Consider developing a code checker using the learned theories within a modern compiler setting.
- **Research and development mentality.** Keep your curiosity to learn the most recent/advanced source code analysis techniques in this course.

# Labs

**Labs:** Hands-on experience includes **preparatory activities** and building the **skills needed for assignments** through completing. Labs are typically not recorded and we may try to record some demonstrations.

- three set of **quizzes** (multiple choice questions)
- three **coding exercises** (small-scale)

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Submission and marking

- Done **individually**
- Submitted a single cpp file in each lab exercise by uploading to WebCMS or via give.
- Automarked (with manual checks and partial marking) against our internal tests.



# Assignments

**Three assignments:** Each assignment is built on the previous one to develop code-checking tools capable of:

- Assignment-1: tracking tainted information flows
- Assignment-2: performing symbolic execution
- Assignment-3: conducting abstract interpretation

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Best practice for completing an assignment (e.g., Assignment-1)?

- **Correct way:** Lab-Quiz-1 → Lab-Exercise-1 → Assignment-1
- **Incorrect way:** all other orders

# Assumed Knowledge

- Should have
  - Experience in writing, debugging, and testing programs in C (COMP2521, COMP9024).
  - Knowledge of using Git and programming IDEs like vim or VSCode.
  - Willingness to learn and open-mindedness.
- Nice to have
  - Some knowledge of object-oriented programming (you will get more practice in C++ programming in our labs).
  - Some background knowledge of compilers (e.g., LLVM and SVF).
  - Some knowledge of secure coding.
  - Experience at different programming "levels" (e.g. low-level, high-level).

# Learning Outcomes

- Practice **system programming skills** to develop **code analysis and verification techniques** to address code security and reliability problems.
  - **High-quality coding**: Commit to writing high-quality, error-free, and high-performance code, especially within the context of large-scale codebases.
  - **Compiler basics**: Gain insights into compilation, code representation, low-level instructions, code debugging and profiling.
  - **Vulnerability Assessment**: Understand common vulnerabilities, such as tainted information flow, buffer overflows, and assertion errors.
  - **Open-source static analysis framework**: learn to build practical tools on top of open-source frameworks like SVF.
  - **Formal Verification**: Understand formal methods and techniques for verifying code correctness using mathematical and logical reasoning tools.

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- Career and job roles
  - Software Engineer; Security Analyst/Engineer; Compiler Engineer; Formal Methods Engineer; Software Reliability Engineer; Embedded Systems Developer; Research Scientist (in Academia or Industry);

# Course Schedule

Week	Content	Lab & Assignment Start	Due (23:59, Wednesday)
1	<b>Lecture:</b> Course Overview and Introduction <b>Lab:</b> C++ practices, vulnerability assessment and compiler IR	Quiz-1 + Exercise-1 (10%)	-
2	<b>Lecture:</b> Control and Data Flows <b>Lab:</b> Code graphs, SVF, constraints solving	Assignment 1 (20%)	-
3	<b>Lecture:</b> Pointer Aliasing and Taint Tracking <b>Lab:</b> Tainted information flow tracking	-	Quiz-1 + Exercise-1
4	<b>Lecture:</b> Code Verification Basis <b>Lab:</b> Verification concepts, predicate logic	Quiz-2 + Exercise-2 (10%)	Assignment-1
5	<b>Lecture:</b> Automated Theorem Proving <b>Lab:</b> Manual assertion-based verification using Z3	Assignment 2 (25%)	-
6	<b>Flexibility Week</b>	-	-
7	<b>Lecture:</b> Code Verification using Symbolic Execution <b>Lab:</b> Automated code assertion verification using Z3	-	Quiz-2 + Exercise-2
8	<b>Lecture:</b> Abstract Interpretation Foundations <b>Lab:</b> Basic concepts and examples	Quiz-3 + Exercise-3 (10%)	Assignment-2
9	<b>Lecture:</b> Code Verification using Abstract Interpretation <b>Lab:</b> Manual assertion-based verification using Z3	Assignment 3 (25%)	-
10	<b>Lecture:</b> Buffer Overflow Detection using Abstract Interpretation <b>Lab:</b> Implementation and testing	-	Quiz-3 + Exercise-3 Assignment-3 (Week 11)

# Assessment Guidelines

- **Joint Work Prohibited:** Collaboration on this assignment is not allowed. Each quiz, exercise, and assignment is submitted and marked individually.
- **Individual Submission:** The work you submit must be entirely your own. Submitting any work, even partially, written by someone else is prohibited.
- **Assessment Marking:** Submissions will be examined both automatically and manually for external authorship.
- **Prohibition on Sharing Work:** Sharing, publishing, or distributing your assignment is not allowed even after the course ends. Do not share your work with anyone other than the COMP6131 teaching staff. **Do not publish your lab or assignment code online (e.g., on a public GitHub repository),** as they may be used by future students.

Violation of these conditions may result in an academic integrity investigation. For more information, read the [UNSW Student Code](#).

# Marking and Plagiarism

- Please refer to specs for each assessment before you start at WebCMS
- No extension is allowed and late submission is strongly discouraged.



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- No extension is allowed and late submission is strongly discouraged.
- The UNSW standard late penalty for assessment is 5% per day for 5 days - this is implemented hourly for this assignment. Your assignment mark will be reduced by 0.2% for each hour (or part thereof) late past the submission deadline.
  - For example, if an assignment worth 60% was submitted half an hour late, it would be awarded 59.8%, whereas if it was submitted past 10 hours late, it would be awarded 57.8%.
- Beware - submissions 5 or more days late will receive zero marks. This again is the UNSW standard assessment policy.
- The marking results will normally be released one week after each submission deadline.

Plagiarism: see [course outline for penalties](#)

# Course Materials and Resources

No single textbook covers all the course content. Recommended references and an abundance of online materials are available below:

- Static Value-Flow Analysis Framework for Source Code
  - <https://github.com/SVF-tools/Teaching-Software-Security-Analysis>
  - <https://github.com/SVF-tools/SVF>
- Compilers: Principles, Techniques, and Tools Hardcover,  
<https://www.amazon.com.au/Compilers-Alfred-V-Aho/dp/0321486811>
- LLVM Compiler <https://llvm.org/>
- Symbolic Execution [https://en.wikipedia.org/wiki/Symbolic\\_execution](https://en.wikipedia.org/wiki/Symbolic_execution)
- Abstract Interpretation  
[https://en.wikipedia.org/wiki/Abstract\\_interpretation](https://en.wikipedia.org/wiki/Abstract_interpretation)
- Z3 Theorem Prover
  - <https://github.com/Z3Prover/z3>
  - <https://theory.stanford.edu/~nikolaj/programmingz3.html>