分类号：H315.9　　　　　　　　　　学校代码：10363
密　级：公开　　　　　　　　　　　学　　号：2221210117

安徽工程大学
Anhui Polytechnic University

硕士学位论文

题目　《自动驾驶汽车的人工智能》（第四章）汉译实践报告

论文作者　费宏宇
校内导师　金成星
校外导师　牟立群
专业学位类别　翻译硕士
研究方向（领域）英语笔译　（工程科技翻译）

论文提交日期：2025 年 5 月 15 日

分类号：H315.9　　　　　　　　　　　　　　　　单位代码：10363
密　级：公开　　　　　　　　　　　　　　　　　学　　号：2221210117

题　　目《自动驾驶汽车的人工智能》（第四章）汉译实践报告

A Report on the E-C Translation Practice of *Artificial Intelligence for Autonomous Vehicles* (Chapter 4)

论文作者：费宏宇

校内导师：金成星

校外导师：牟立群

专业学位类别：翻译硕士

研究方向（领域）：英语笔译（工程科技翻译）

论文答辩日期：**2025 年 5 月 14 日**

安徽工程大学学位论文原创性声明

本人郑重声明：我恪守学术道德，崇尚严谨学风。所呈交的学位论文，是本人在导师的指导下，独立进行研究工作所取得的成果。除文中已明确注明和引用的内容外，本论文不包含任何其他个人或集体已经发表或撰写过的作品及成果的内容。论文为本人亲自撰写，我对所写的内容负责，并完全意识到本声明的法律后果由本人承担。

学位论文作者签名：

日期：2025 年 5 月 15 日

安徽工程大学学位论文版权使用授权书

学位论文作者完全了解学校有关保留、使用学位论文的规定，同意学校保留并向国家有关部门或机构送交论文的复印件和电子版，允许论文被查阅或借阅。本人授权安徽工程大学可以将本学位论文的全部或部分内容编入有关数据库进行检索，可以采用影印、缩印或扫描等复制手段保存和汇编本学位论文。

保密 □，在 ____ 年解密后适用本版权书。

本学位论文属于

不保密 ☑。

学位论文作者签名：　　　　　　指导教师签名：

日期：2025 年 5 月 15 日　　　　　　日期：2025 年 5 月 15 日

致　谢

三年笔译研途，如诗行渐次铺展，终至尾声。我从青涩走向成熟，此刻满是感恩。

我诚挚地感谢我的导师金成星教授。他以深厚的学术造诣为墨，为我勾勒翻译世界的广袤图景。从论文的选题立意至谋篇布局，他都给予细致入微的指导。他的言传身教，不仅提升我的专业素养，更塑造了我严谨的学术品格。学院的诸位授课老师，也是我学术成长的重要引路人。他们在课堂上旁征博引，将翻译技巧与文化内涵娓娓道来，不同课程的知识相互交织，构建起我坚实的专业知识框架。

感谢同窗挚友，那些为翻译难题争得面红耳赤的研讨时光，成为研途难忘的风景。我们共享资料、交流心得，在彼此的激励中共同进步。感谢家人朋友，对我的选择无限支持，让我人生的画卷愈加多彩鲜活。

这段旅程虽将结束，但学无止境。我会带着这份感恩，在翻译之路上笃定前行，以笔为媒，传递语言之美。

摘　要

本次翻译实践选材于多位学者合著的《自动驾驶汽车的人工智能》。该著作于 2024 年 2 月由世界第三大学术期刊出版商 Wiley 国际出版公司以及专注工程等领域的 Scrivener Publishing 共同出版，文本内容较为前沿。本书通过 11 个章节介绍自动驾驶汽车以及 AI 在自动驾驶汽车中的应用，探讨了用新型 AI 算法解决目前自动驾驶汽车算法存在的局限和弊端，对自动驾驶汽车发展有较高的研究价值。译者选取该书的第四章作为翻译文本。它主要介绍了自动驾驶汽车的体系结构。本次翻译实践在促进自动驾驶汽车相关知识传播、技术交流、科普介绍等方面具有很重要的意义。

此次翻译的重难点在于：一是半技术词汇的准确表达。译者可基于专业领域、平行文本确定词义。二是长难句的翻译，尤其是含有定语从句和状语从句的长难句的翻译。含有定语从句的长难句可以通过前置法、分译法、综合法来翻译，含有状语从句的长难句可使用逆序法、转换法进行翻译。三是译文语义连贯的再现。为了实现交际功能，可使用回指的明示、语义的增译来再现译文的逻辑，增强可读性。

通过本次翻译实践，译者深刻地体会到：在翻译科技领域相关文本时，译者应该具备扎实的汽车、人工智能、物理等多重领域的相关知识，以确保译文的准确性和专业性。此外，译者还应具有读者意识，熟练运用翻译技巧，确保译文的可读性和流畅性。在翻译的过程中，译者不仅了解了专业领域的翻译特点，提升了篇章意识和读者意识，还锻炼了信息搜索和查证能力，为今后的翻译工作奠定了良好的基础。

关键词：　《自动驾驶汽车的人工智能》；半技术词；长难句；语意连贯

Abstract

This translation practice selects materials from the book *Artificial Intelligence for Autonomous Vehicles*, co-authored by multiple scholars. The book was jointly published in February 2024 by Wiley, the world's third-largest academic journal publisher, and Scrivener Publishing, which focuses on fields such as engineering. The content of the text is relatively cutting-edge. Through 11 chapters, this book introduces autonomous vehicles and the application of AI in autonomous vehicles, and explores the use of new AI algorithms to address the existing limitations and disadvantages of current algorithms for autonomous vehicles, which holds high research value for the development of autonomous vehicles. The translator has chosen the fourth chapter of this book as the translation text, which mainly introduces the architecture of autonomous vehicles. This translation practice is of great significance in promoting the dissemination of knowledge related to autonomous vehicles, technical exchanges and popular science introductions.

The key and difficult points of this translation are as follows: Firstly, the accurate expression of semi-technical words. The translator can determine the meaning of words based on the professional field and parallel texts. Secondly, the focus should be on the translation of long and difficult sentences, especially those containing attributive clauses and adverbial clauses. Long and difficult sentences with attributive clauses can be translated through the methods of preposition, division, and integration, while long and difficult sentences with adverbial clauses can be translated by using techniques such as inverse-order translation, and conversion. Thirdly, the reproduction of semantic coherence in translation is stressed. In order to achieve the communicative function, the explication of anaphora and the addition of semantic content can be used to reproduce the logic of the translation and enhance its readability.

Through this translation practice, the translator has deeply realized that when translating texts related to the field of science and technology, the translator should possess solid knowledge in multiple fields such as automobiles, artificial intelligence, and physics to ensure the accuracy and professionalism of the translation. In addition, the translator should also have a reader awareness, and be proficient in using translation techniques, so as to ensure the readability and fluency of the translation. During the translation process, the translator has not only gained knowledge of the translation characteristics of the professional field, enhanced the awareness of text cohesion and the reader awareness, but also improved the ability to search for and verify information, which has laid a good foundation for her future translation work.

Key Words: *Artificial Intelligence for Autonomous Vehicles;* semi-technical words; long and difficult sentences; semantic coherence

目　录

第一章 任务简介

1.1 源文本介绍

自动驾驶汽车是当今汽车行业和人工智能领域最前沿的话题之一，从一开始仅出现在科幻片中的自动驾驶汽车已经逐渐进入人们的日常生活，科技让曾经的那些“天马行空”变为现实。越来越多的人们开始关注自动驾驶汽车，开始了解自动驾驶汽车中的人工智能。

《自动驾驶汽车的人工智能》（*Artificial Intelligence for Autonomous Vehicles*）是由世界第一大独立的学协会出版商和第三大学术期刊出版商 Wiley 国际出版公司以及成立于 2009 年专注于计算机科学、数据科学和工程等领域图书的 Scrivener Publishing 共同出版。全书分为 11 个章节，主要介绍了自动驾驶汽车的构成、AI 在自动驾驶汽车中的应用，以及探讨用新型 AI 算法解决目前自动驾驶汽车算法存在的局限和弊端。该书于 2024 年 2 月首次出版，目前尚未出现中文译本，因此此次翻译具有很强的时效性，对汽车行业优化自动驾驶汽车中的人工智能具有一定的参考价值。

本次翻译实践任务为翻译《自动驾驶汽车的人工智能》一书的第四章，译文 17000 余字，符合 MTI 翻译实践报告的相关要求。该章节主要介绍了自动驾驶汽车的体系结构，包括 AI 和自动驾驶汽车的概念和架构、技术的应用、分析目前架构中存在的不足，以及自动驾驶汽车的优势，预测自动驾驶汽车未来发展的趋势。翻译该章节可为自动驾驶汽车领域相关专业人士以及爱好者们提供参考或进行科普介绍。

1.2 实践意义

翻译工程科技类文献既是打破国际科技知识传播壁垒的有力工具，也是为各领域发展注入创新活力并为个人成长赋能的重要桥梁。

首先，随着全球科技竞争的日益激烈，自动驾驶技术作为新兴的关键领域，对于交通、科技、产业升级等方面的发展布局至关重要。此次翻译实践有助于促进国内外该领域的技术交流与合作，推动国家引进先进的自动驾驶技术理念和研发成果。

其次，此次翻译实践有助于促进自动驾驶汽车知识在社会中的广泛传播，让更多的人能够了解这一前沿技术的优势、不足以及发展前景，为未来自动驾驶汽车的普及

和提升社会接受度奠定基础。

最后，译者通过此次翻译实践，深刻地了解自动驾驶汽车这一热门领域的知识体系，把握了相关领域的专业术语和背景知识，初步掌握了工程科技文献的翻译技能，提升了相关领域文献的翻译能力，为将来的职业发展奠定了良好的基础。

第二章 译前准备

译前准备工作和翻译质量息息相关。对于工程科技类文本的翻译，译者不仅需要掌握相关专业知识背景，还要对文中出现的专业术语进行准确的查验；同时，还要根据不同的受众，选择合适的语言风格和翻译技巧。

2.1 源文本特征分析及翻译原则

2.1.1 源文本的特征分析

本次翻译实践报告所翻译的文本选自于《自动驾驶汽车的人工智能》（*Artificial Intelligence for Autonomous Vehicles*）中的第四章，主要介绍了自动驾驶汽车的体系结构，是一篇科技类文献。科技文体是一种信息语言体，其主要内容具有客观性和科学性，可定义、可比较、可计量、可验证形成了自身的用词、句法、文体特点（何三宁，2011：29）。源语文本专业性强，逻辑严谨，语言精炼。在词汇层面，文中用词规范、简洁、准确，大量使用了计算机领域、汽车领域、光学领域等的专业术语和缩写词，传达特定的概念和信息，还大量使用了半技术词汇，体现文章的专业性和技术性；在句子表达层面，文中采用了较多长难句，这些结构严谨的长句对某些概念和功能进行介绍，需要仔细分析句子结构和逻辑关系，准确理解句子的含义；在篇章段落方面，文章采用了总分总的结构，首先介绍了人工智能和自动驾驶汽车的基本概念，然后从架构、功能、优势、未来发展趋势等方面进行详细阐述，最后总结自动驾驶汽车的发展前景；介绍问题由浅及深，层次清晰，段落之间衔接严谨，整体逻辑清晰。

纽马克把源语文本划分为三种文本类型：表达型文本（expressive texts）、信息型文本（informative texts）和呼吁型文本（vocative texts）。纽马克认为信息型文本包括教科书、论文学术报告、报刊文章、科学论文、毕业论文和会议记录等（Newmark, 2001: 136）。译者选择的源文本章节属于典型的科学论文，属于信息型文本，信息型文本的核心在于展现源文本信息内容的客观真实性（true）。译者应再现源文本的准确性和专业性。华蘅芳主张“其文义但求明白晓畅，不失原书之真意”，前句即求译文之“达”，后句则指译文需“信”（张必胜，2023：73）。人们使用语言的最终目的是实现一定的交际功能，鉴于译文受众包括自动驾驶汽车领域专业人士以及该领域的爱好者，故译文要以目标语为导向，注重交际的有效性和准确性，在保证专业性的前提下尽量做到流畅、通顺。

2.1.2 源文本的翻译原则

根据纽马克的文本类型理论，信息文本应以交际翻译法为主，强调意义优先于形式，译者有权重新组织句法、消除原文晦涩难懂或造成理解障碍的地方，调整原文的逻辑关系，更为注重接受者的理解和反应（Newmark, 2001: 177）。科技类文本翻译的难点在于如何在确切理解原文的基础上确切地再现原文的信息，如何按照译文习惯重新安排结构以保持逻辑连贯，如何处理中文里特有的表达方式，而要做到这些，需要有创意（蔡力坚，2023：157）。故此，此次翻译应遵循以下原则：

1. 忠实准确

“信息型文本”特别是科技性文本讲究表达的专业性，因此对于科技语篇中的术语必须百分之百的忠实即遵循“信”的原则。信息型文本以传递信息为主要目的，着重体现语言的信息功能，忠实准确地传递源文本作者所表达的信息为首要目标。因此，信息型文本翻译的首要标准就是“忠实准确”，译文必须忠实于原文，客观准确地表达源文本传递的信息。译者需要了解原文背景和意图，对于原文所表达的内容必须准确无误地表达，不可随意地对原文做太多改动。

2. 通顺流畅

所谓“通顺”，就是在忠实于原文意思或意图的基础上，按照译入语的写作规范进行翻译（李长栓，2025：14）。译者应重视译入语读者是否和原文读者获得相同的阅读感受，若译文晦涩难懂，那么信息传递是无效的。所以，必须重视译文的通顺流畅，让译文在读者中的印象和原文基本相同。这就需要译者正确理解原文信息，适当对原文做出调整，以便符合译入语读者阅读习惯，避免出现翻译腔。

3. 规范专业

科技英语语篇不同于评论性的社论，不是抒发情感的诗歌、散文或小说，它属于特定的信息语篇类型，旨在呈现事实、证明假设（高巍、孙凤兰，2020：29）。科技文体是一种正式文体，读者也拥有一定的背景知识，翻译时对译文的规范、专业有很高要求。所以，必须要做到规范专业。这就要求译者尽可能了解相关文本的特点，不断积累特定领域的相关背景知识；提高查阅资料的能力，不断向相关领域专家求教，以确保译文的规范专业。

2.2 平行文本的收集

平行文本是指与原文内容、话题相似的文本。因翻译材料专业性较强，收集平行文本有利于弥补译者相关专业知识的空白，同时，有利于对术语的精准把握，提高译文的准确性，展示信息型文本的专业性。

此次翻译实践材料属于自动驾驶汽车行业，需要查阅有关自动驾驶汽车相关文本，如 Michael E. McGrath 撰写的 *Autonomous Vehicles: Opportunities, Strategies and Disruptions*；Anthony Raymond 撰写的 *How Autonomous Vehicles Will Change the World*，对自动驾驶汽车的构造进行初步的了解。随后，查阅清华大学出版社出版的《自动驾驶汽车平台技术基础》、《偏振光和光学系统（第一卷）》；电子工业出版社出版的《光电子学与光子学——原理与实践（第二版）》等书，了解自动驾驶汽车的正确的中文术语表达，纠正理解有误的复杂概念。同时，通过与源文本进行比较，确定相关词汇、概念的规范表达，以确保译文的专业性，平行文本的收集在一定程度上弥补了译者专业和语言的不足。

2.3 术语表的建立

术语的统一和规范是应用翻译，特别是大规模翻译项目中首先要解决的问题。对重复性事物的概念采用统一的、标准的术语是翻译工作的基本要求（方梦之，2014：4）。术语表对于翻译人员来说必不可少，可以统一翻译标准，明确相关术语的表达，以确保信息型文本的专业性，提高翻译的效率和质量。

此次翻译实践材料涉及来自各行各业的术语，那些看似简单，甚至常见的单词，在不同领域有着特定的含义，需要译者反复查阅相关书籍、网站，咨询相关领域专家、对比 CNKI 相关文献来确定。译者通过机器辅助翻译工具 Trados 提取术语，并通过以上步骤，最终确定了所有术语的准确译法，术语表在附录 1 中。

2.4 翻译工具的选择

在翻译过程中，使用翻译工具能快速查询术语、提供整句的完整翻译，大幅提高翻译效率。翻译工具依靠权威资源给出标准译法，还可提供相关参考例句，有利于帮助译者理解、处理逻辑复杂的句子。此外，翻译工具可适应不同的文本风格，给出相应的翻译风格调整建议，提高译文质量与效果。

1. 纸质词典

译者主要使用柯林斯高阶英汉双解学习词典（英国柯林斯出版公司，第 9 版，北京：外语教学与研究出版社，2023）进行一词多义词汇的辨析，其可提供例句帮助译者进行词义的恰当选择。

2. 软件词典和翻译软件

译者主要使用网易有道词典、必应词典等在线词典快速查询各类专业术语和缩略语，其更新速度快，可确保翻译的专业性和准确性，使译文符合行业规范，便于专业读者理解。此外，译者使用 Trados 软件进行术语的处理，Trados 可帮助译者快速筛选文章中的专业术语，并提供相关译法，经过译者查证后，即可制成术语表。

3. 术语网站

译者主要使用中国汽车产业数字化图书馆（https://www.autolab.org.cn）、术语在线（https://www.termonline.cn/index）等网站进行复杂概念翻译的验证以及进行相关知识的补充。

第三章 案例分析

在《自动驾驶汽车的人工智能》第四章的翻译实践中，诸多复杂且关键的问题接踵而至。首先，半技术词汇在不同语境下的表意模糊，极大地阻碍了信息传递的精准性。同时，文本中大量长难句频繁出现，尤其是包含定语从句和状语从句的句式，其结构复杂，对某些复杂概念和功能进行介绍，介绍内容专业性强，导致译者难以理解，增加了翻译难度。此外，译文语义连贯的再现同样不容忽视。若不能妥善处理，则不便于读者阅读理解。秉持以问题为导向的意识，通过本章的案例分析，深入探寻切实可行的解决方案，以提升翻译质量。

3.1 半技术词汇的准确表达

半技术词汇的准确表达是翻译的一大难题。有些半技术词汇，兼具专业性与灵活性，其含义常因专业领域、上下文语境的不同而产生微妙变化。这些半技术词汇含义的不确定性，极大地干扰了翻译的准确性，也给译文的专业性与可靠性带来了挑战。

作为专门用途英语（English for special purposes），科技英语以客观事物为中心，用词上讲究准确明晰，论述上讲究逻辑严密，表述上则力求客观（韦孟芬，2015：1）。科技英语的术语一般包含技术词和半技术词汇，这些词汇的翻译与译文的专业性与准确性息息相关。已经有官方翻译规范的术语，译者应遵循这些规范，确保翻译的准确性和权威性。而对于那些尚未有统一翻译的术语，译者需要在没有规范指导的情况下做出判断（秦艳霞、刘德连：2024：59）。对于技术词而言，一般可通过参照平行文本的既有翻译或请教专家予以解决，而半技术词则常常需要译者根据专业领域或基于平行文本推定。

3.1.1 基于专业领域确定词义

半专业技术词不具有严格的体系性，词义取决于文本所属专业领域和与相关词形成的联立关系（方梦之，2011：54）。翻译时要基于专业领域来确定词义，充分考虑词汇的使用场合、涉及学科，“因地制宜”翻译出准确的词义，否则就会词不达意，影响文本内容的理解。

例 1：In scenarios with a High Dynamic Range (HDR), such as when entering or exiting a tunnel, both dimly lit and brightly lighted areas can be visible in the same <u>frame</u>.

译文 1：例如进出隧道，在同一框架中同时可见昏暗和明亮区域的高动态范围（HDR）场景中。

译文 2：在高动态范围（HDR）场景中（例如汽车进出隧道时），在同一帧（画面）中可同时呈现昏暗光照区和明亮光照区。

分析："frame"是半技术词汇，译文 1 将其译为"框架"，这是其的常见释义之一。然而，在本句语境所描述的场景与计算机图形学和电影摄影术领域相关，且涉及高动态范围（HDR）相关概念时，"框架"这一释义显得与语境不太契合。"框架"通常用于描述具有实体结构或宏观架构的事物，而在此句中，其语义难以准确传达句子所表达的关于图像或视觉场景的信息。进一步从专业领域知识角度分析，句中出现专业术语 HDR（高动态范围），这是在图像处理领域广泛应用的术语。在该领域中，"frame"更常被理解为"帧"，指的是构成视频、图像序列的单个图像单元。

随后，译者经检索发现，原文作者在表达宏观的"框架"概念时，始终使用"architecture"一词，原文中多次出现的"frame"均出现在自动驾驶汽车探测周围事物所涉及的雷达、立体视觉等相关句子中，这些场景同样与图像处理和视觉信息获取紧密相关，进一步印证了将"frame"译为"帧"的合理性，同时增加"（画面）"一词帮助读者理解其属于图像领域。最后，译者将"（例如汽车进出隧道时）"处理为在高动态范围（HDR）场景中的案例补充，便于读者更加清晰地了解句子间的逻辑关系，在译文 2 中予以体现。

例 2：In contrast to the lower divergence laser emitter used in LiDAR, using a non-directed light source has benefits such as capacity to produce high refresh rate (above 50Hz) and detailed depth maps.

译文 1：与激光雷达使用的较低差异激光发射器相比，采用非定向光源更具益处，如能产生高刷新率（50 赫兹以上）和详细的深度图。

译文 2：与激光雷达（LiDAR）使用的较低散度激光发射器相比，采用非定向光源更具益处（如能产生高刷新率（50 赫兹以上）和精细的深度图）。

分析："divergence"是半技术词汇，在柯林斯字典中的主要释义为"the process or state of diverging"，对应常见的中文含义是"不同、差异"。译文 1 将其简单译为"较低差异的激光发射器"，从语言表达角度看，"较低差异"与"激光发射器"的搭配不恰当，不符合正常的语言习惯和技术领域的表述方式。句中还出现了"LiDAR（激光雷达）"以及"laser emitter（激光发射器）"这些关键术语，由此可以明确该句

讨论的内容处于激光雷达技术领域。在激光雷达相关的专业知识体系中，“divergence”常被理解为“散度”，准确地反映出激光在传播过程中的扩散程度，与激光雷达技术中对激光发射器性能的描述紧密相关。随后，译者为突出原文对比之意，将举例说明部分置于括号中，以突出重点“更具益处”（见译文 2）。

3.1.2 基于平行文本确定词义

通过查找专业的自动驾驶技术论文、行业报告、书籍等平行文本，能发现不同作者在相似语境下对该词汇的使用方式和解释说明，为译者在本次翻译中准确确定词义提供了关键线索，以解决因词义不明导致的翻译错误。

例 3：Light polarization sensors, which consistently function under challenging weather circumstances and provide unusual sorts of information, are the subject of active study.

译文 1：光极化传感器可在恶劣天气条件下持续工作，提供独特的信息，目前是热门的研究课题。

译文 2：光偏振传感器可在恶劣天气条件下持续工作，提供独特类型的信息，目前是热门的研究对象。

分析：“polarization”本身具有“极化”和“偏振”这两个主要释义，在缺乏足够专业背景知识的情况下，很难直接判断“light polarization sensors”究竟应译为“光极化传感器”还是“光偏振传感器”。通过查阅美国学者 Russell Chipman、Wai Sze Tiffany Lam、Garam Young 所著的 *Polarized Light and Optical Systems* 及其权威中文译本《偏振光和光学系统（第一卷）》中，“polarized”和“polarization”均被译为“偏振”。进一步以“光偏振传感器”和“光极化传感器”作为关键词在 CNKI（中国知网）这一权威学术数据库中进行检索。检索结果显示，绝大多数相关文献在描述该类传感器时，均使用“偏振传感器”的搭配，而“光极化”在专业文献中更多是以“optical poling”的术语形式出现，再次印证了“偏振”才是“polarization”在“light polarization sensors”这一表述中的准确含义，符合该领域的专业规范与表达习惯。此外，译者将译文 1 中的“研究课题”优化为“研究对象”，因为“光偏振传感器”是一个光电原件，更符合专业实际。

例 4：The shift of phase of the approaching light that is converted to a distance can be used to determine the duration of each pixel’s round-trip.

译文 1：接近光的阶段变化可转换为距离，用来确定每个像素往返的持续时间。

译文 2：接近光的相位偏移可转换为距离，用来确定每个像素往返的持续时间。

分析：此句专业性较强，“phase”为半技术词汇，在不同语境下有不同释义，这给翻译带来了较大难度。译文 1 将其译为“阶段”，从字面本意理解。而该段落主要阐述雷达测距原理，在这个专业语境下，“阶段变化可转换为距离”的表述不太合适，因为在雷达测距相关理论里，与距离转换密切相关的并非是光的“阶段”概念，而是光的某种特定物理属性的变化。为解决这一翻译难题，译者查阅了英国学者 vS.O.Kasap 所著的专业教材 *Optoelectronics and Photonics* 及其权威中文译本《光电子学与光子学——原理与实践（第二版）》，在该专业文本中，“phase shift”被明确译为“相移”，基于此，译者可以确定“phase”在雷达测距这一专业领域中应理解为“相位”，而不是“阶段”。

原句中的名词化结构“the shift of phase of the approaching light”重点强调的是“shift（变化）”这一动作。因此，将其灵活处理为“相位偏移”，更能准确传达原文强调相位状态改变的意图。在专业领域中，“相位偏移”一词更能突出相位状态动态改变这一关键事实，使译文在专业术语的运用上更加贴合专业语境，准确地传达原文所蕴含的专业信息。

3.2 英语长难句的准确传译

英语重形合，逻辑严谨，多用长句表达。因为这些句子的主干附有各种从属结构，包括介词短语、非限定性短语、各种从句及分句等。这些结构环环相扣，句中有句，使得整个句子不仅信息含量大，而且句子结构和逻辑关系复杂（李帅、孙成杰，2016：74）。尤其是信息类文本，由于其专业性，必须使用某些修饰成分或逻辑复杂的句型做出限定和规范，导致本次翻译实践材料中英语长难句较多，增加了翻译的难度。在分析长句时首先要通读全句初步了解全句的大意。其次，要通过语法分析句子的结构，弄清主句、从句和短语。然后，根据主从关系找出句子的中心内容和各层意思，并分析各层意思之间的逻辑关系（于建平，2000：15）。本次翻译实践材料中含定语从句和状语从句的长难句较多，且定语从句准确修饰核心要素，层层嵌套，关系复杂。状语从句精准设定条件限制，逻辑严谨。

3.2.1 含定语从句的长难句的翻译

本次翻译实践材料中，定语从句较多，结构复杂，是本次翻译的难点之一。又因

信息型文本的特殊性，译者要在一定程度上保留原文的专业性，又要将复杂的句式流畅化。不论是将长句拆成短句，还是打乱原文结构，重新组合，得出的译文必须做到原文所传达的信息不能少，原文的通顺流畅不能丢，原文的气势不能减，原文的节奏不能变（刘庆荣，2009：70）。

3.2.1.1 前置法

一般将较短的定语从句译成汉语的定语词组或带“的”字结构。放在所修饰的中心词之前，从而使从句和主句合成一个句子，这就是前置译法（袁瑛，2010：7）。

例 5：Artificial intelligence impact is an event where the capability of tools is more, moves that were once thought to need intelligence are now frequently excluded as more competent according to the concept of AI.

译文 1：人工智能的影响是这样一种事件：如今工具的能力愈发强大，依据人工智能的概念，有些行为曾经被认为需要智能才能完成，现在常常因为更强的能力而排除在外。

译文 2：人工智能的影响体现为工具能力增强。那些曾被认定需要智能才能完成的动作，随着人工智能的概念的演变，如今常常不再需要了。

分析：本句话较长，介绍内容难以理解，翻译时有一定难度。要想理清句子逻辑，可先对句子进行断句处理 Artificial intelligence impact is an event ①where the capability of tools is more, moves ②that were once thought to need intelligence / are now frequently excluded as more competent according to the concept of AI.本句话的主干为主系表结构的“Artificial intelligence impact is an event”，点明核心主体，阐述该影响的性质。同时，定语从句①修饰先行词 event，地点状语 where 等同于 in this event，建立起事件与工具能力的关联，修饰限定功能十分明显。定语从句②修饰 moves，内部的“that were once thought to need intelligence”点名这些“动作”以前需要智慧支撑，与后句“are now frequently excluded as more competent according to the concept of AI”形成对比。

该句主体为“Artificial intelligence impact is an event”，又包含两个定语从句，译文 1 想要展现原文的逻辑，在翻译定语从句时并未使用前置法，造成定语从句①和主句割裂，没有精准的传达原文的逻辑，定语从句②读起来生硬晦涩。译文 2 对定语从句前置翻译，将定语从句①“Artificial intelligence impact is an event where the capability of tools is more”译为“人工智能的影响体现为工具能力增强”；定语从句②“that were once thought to need intelligence”译为“那些曾被认定需要智能才能完成的动作”。先用首句定义此次事件，然后介绍这些行为前后变化，突出对比之意，逻辑更加清晰。此外，译者发现译文 1“现在常常因为更强的能力而排除在外”不易于读者接受，译为“如今常常不再需要了”更通顺易懂，简洁地表达与前文的对比，最终形成译文 2。这样译文逻辑更清晰，语句更通顺。

例 6：A solid-state oscillating micro mirror and optical phased array are two of the technologies that fall under the general term “LiDAR,” which covers several more optical phased array (OPA).

译文 1：固态振动微型镜和光学相控阵这两种技术，都属于统称“激光雷达”，还包括其它光学相控阵（OPA）。

译文 2：固态振荡微镜和光学相控阵是属于统称“激光雷达”下的两种技术，激光雷达还包括其它多种光学相控阵（OPA）。

分析：本句包含了两个定语从句，定语从句①“that fall under the general term”，“LiDAR”修饰“two of the technologies”，说明固态振荡微镜和光学相控阵这两种技术所属的范畴；非限制性定语从句②“which covers several more optical phased array (OPA)”是对“LiDAR”进行补充说明。译文 1 单独翻译两句定语从句，句子衔接不流畅，尤其定语从句①的翻译读起来不符合中文表达习惯，且“固态振动微型镜”表达也不够专业。译文 2 将定语从句①采用前置法进行翻译，这样能够让读者迅速理解这两种技术和激光雷达之间的所属关系，最后将非限制性定语从句②单独成句，体现补充说明的性质，逻辑流畅，体现工程科技文本的严谨性。

3.2.1.2 分译法

定语从句对先行词的限制性较弱，描述性或解释性较强，并且结构复杂的时候，往往将定语从句和先行词分开，译成和主句并列的分句，以符合汉语的表达习惯（孔德亮，2013：7）。在科技文本翻译中，有些句式过长、逻辑复杂。可采用分译法，将英语长句翻译为多个中文短句。

例 7：Time-of-flight: It is a form of active sensing that operates on the identical round-trip time theory that an infrared LED emitter floods the image with changed light, which, after being reflected by numerous things in the surroundings, is then captured by the sensor.

译文 1：飞行时间法：它是一种主动传感形式，基于相同的往返时间理论运行，即红外发光二极管发射器用经过变化的光覆盖图像，这种光在被周围众多物体反射后被传感器捕捉。

译文 2：飞行时间法是一种主动传感形式。其基于相同往返时间理论运行，即通过红外发光二极管（LED）发射器发出调制光来照亮图像。这种光被周围物体反射后，由传感器捕获。

分析：本次翻译实践材料中，对于复杂理论的解释，作者喜欢用定语从句循环套译来表达逻辑的严谨，这样可以确保原文语言的专业性，但确实增加了翻译的难度。由前置词可以看出，这句话主要介绍的是飞行时间法，并指出其是一种主动传感技术，为后续定语从句深入阐述奠定基础。可先根据连接词对句子进行划分：Time-of-flight: It is a form of active sensing ①that operates on the identical round-trip time theory ②that an infrared LED emitter floods the image with changed light, ③which, after being reflected by numerous things in the surroundings, is then captured by the sensor.

定语从句①修饰先行词 active sensing，说明其核心原理，奠定逻辑基础；定语从句②详细解释前面的 theory，解释该理论的具体内容；最后用 which 引导的非限制性定语从句③修饰 changed light，呈现光线反射后被捕捉的过程。构建了从理论到实践的完整语义链条，严密分析飞行时间法。译文 1 保留原文表达顺序，仅在连接词处划分，没有展现出原文三个定语从句组合的特点，整体逻辑不够清晰。同时将“changed light”错译为“变化的光”，未能展现原文的专业性。译文 2 首先对整体结构进行拆分，将“Time-of flight: It is a form of active sensing”单独提取出来，译为“飞行时间法是一种主动传感形式”，这是对飞行时间法本质属性的说明，译为一个独立的句子，清晰地界定了核心概念。其次将定语从句拆分单独成句，定语从句①译为“其基于相同的往返时间理论运行”，使该理论成为一个独立的陈述内容，强调了这种传感形式的运行依据，让读者能更清晰地理解其工作基础。将定语从句②独立成句后，详细解释了理论的具体操作，使逻辑更加清晰。定语从句③单独成句后描述了光线的传播和接收过程，进一步细化了工作原理，使整个过程的描述更加条理清晰。

例 8：A well-known stable signal with another continuous signal that modulates it with an up-and-down frequency variation is what makes up FMCW (typically using a triangular shape).

译文 1：一个众所周知的稳定信号和另一个用上下频率变化对其进行调制的连续

信号组成了调频连续波（FMCW）（通常使用三角形）。

译文 2：一个稳定的已知信号与另一个连续信号相结合，后者通过上升和下降的频率变化来调制，这就构成了调频连续波（FMCW）（通常使用三角形形状）。

分析：原句是典型的主系表结构。主语部分由“a well-known stable signal with another continuous signal”构成，其中“with another continuous signal”充当伴随状语，进一步补充说明主语。而“that modulates it with an up - and - down frequency variation”这一定语从句，紧紧围绕“another continuous signal”展开，详细阐述其如何对稳定信号进行调制。谓语为 is，表语则是由 what 引导的表语从句“what makes up FMCW”。

译文 1 采用前置法翻译定语从句，把修饰“another continuous signal”的定语从句直接置于其前，形成“另一个用上下频率变化对其进行调制的连续信号”这样的表述。这种方式虽符合常规定语从句前置规则，但在本句中，主语已包含两个信号描述，再加上冗长的定语从句前置，导致主语过于复杂冗长，句子结构失衡，读起来晦涩拗口，理解难度显著增加。译文 2，运用分译法，将 that 译为“后者”，明确指向“another continuous signal”，同时，把表语从句连接词 what 译为“这”，并将该句处理为总结句，即“这就构成了 FMCW（通常使用三角形形状）”。如此一来，先分别阐述稳定信号与连续信号及其调制关系，最后总结得出构成 FMCW 的结论，逻辑链清晰明了，极大地提升了读者的理解效率。

例 9：The functioning of a single monocular camera shifts an artificial baseline between subsequent frames, which is employed in monocular SLAM (simultaneous location and mapping) algorithms to evaluate depth and camera motion.

译文 1：单个单目相机的功能会在后续帧之间移动人工基线，这在单眼 SLAM（同时定位和映射）算法中用于评估深度和相机运动。

译文 2：单个单目相机的运行会在后续各帧图像之间产生人工基线偏移，单目 SLAM（同步定位和地图构建）算法中利用此偏移来评估深度和相机运动的情况。

分析：此句的核心结构为“The functioning of a single monocular camera shifts an artificial baseline between subsequent frames”，阐述单目相机运作核心效果。“which is employed in monocular SLAM (simultaneous location and mapping) algorithms to evaluate depth and camera motion”为非限制性定语从句，修饰“an artificial baseline”，起补充说明作用，精准说明人工基线在即时定位与地图构建算法中的关键作用。译文 1、2 均采用了分译法，因主句和定语从句长度相似，译文 1 根据原文中逗号的分隔翻译

为两句话，将定语从句单独译出，但译文弱化了其作用，没有展现原文的目的。译文2依旧将原文分译为两句话，但将动词“shift”处理为名词表达“偏移”。这样，前句介绍单目相机的功能，后句介绍 SLAM 利用这种偏移的目的，译文的层次性更强，便于读者阅读。

3.2.1.3 综合法

当单一翻译技巧不足以确保译文通顺、语义连贯时，可依据句式的具体特征，综合运用多种技巧。让译文契合目标语读者的文化背景与阅读习惯，进而实现译文语义连贯、逻辑严密。

例 10：An investigation of intelligent agents that perceive their environments that react in a manner that maximizes their success chances might be characterized as AI research.

译文 1：将那些能够感知环境并以最大化成功机会的方式做出反应的智能代理进行研究，可以被视为人工智能研究。

译文 2：能够感知自身所处环境的智能主体，其感知方式可以使自身成功的几率最大化。对于这样的智能主体的研究，可能被视为人工智能研究。

分析：该句包含三个定语从句的循环套译，逻辑严谨，翻译难度很大。首先对句子进行划分，以便捋清逻辑：An investigation of intelligent agents <u>①that perceive their environments / ②that react in a manner / ③that maximizes their success chances /</u> might be characterized as AI research.此句的主干是“An investigation of intelligent agents might be characterized as AI research”，明确句子的核心是对其关系的阐述。划线句子为定语从句修饰先行词“intelligent agents”，此部分包含三个层层嵌套的定语从句，而主语中也包含 of 结构，对这四个“的”的处理成为翻译该句的难点。因句子较难理解，译者首先采用分译法将划线部分的定语从句分为三部分，标为①②③。定语从句①修饰的是“intelligent agents”，从基本功能特性角度对主语进行修饰；定语从句②修饰①中的环境，是对“intelligent agents”的进一步修饰；定语从句③修饰的为②中的方式，是对“intelligent agents”的深入限定。整个定语从句呈现循环套译的结构，逻辑严谨，显示了本次翻译实践材料的专业性。

译文 1 按照传统的前置法的方式，将修饰成分前置，导致翻译出的句子头重脚轻，不便于读者阅读，多个“的”的累计，也会让读者抓不住重点。在译文 2 中，①句使用前置法翻译为“感知自身环境的智能主体”，②句分译为“以某种方式反应

环境”，③句分译为“最大化成功的方式”。②③都在形容方式，①描写的另一事物，故将这三句分为①、②③两部分。将定语从句①单独译出，②③为体现原文对方式形容的逻辑性，按照原文逻辑顺序翻译，随后加上主谓宾。译文 2 中，综合采用了前置法、分译法、顺译法的翻译手段，译文读起来更流畅，逻辑更加清晰。

例 11：The model-based predictive control (MPC), which manages the lateral control that provides the engineering signal, optimizes a cost function over a preset time horizon H, producing a series of actions, one for each time step △t.

译文 1：管理提供工程信号的横向控制的基于模型的预测控制（MPC），在预设的时间范围 H 内优化成本函数，产生一系列动作，每个时间步长∆t 对应一个动作。

译文 2：基于模型的预测控制（MPC）管理提供工程信号的横向控制。MPC 在预设的时间范围 H 内优化成本函数，从而产生一系列动作，每个时间步长∆t 对应一个动作。

分析：此句的核心为“The model-based predictive control (MPC) optimizes a cost function over a preset time horizon H”，指明 MPC 的核心任务，非限定性定语从句“which manages the lateral control that provides the engineering signal”修饰 MPC，进一步说明 MPC 的功能，其中嵌套限定性定语从句“that provides the engineering signal 修饰 the lateral control”。随后现代分词短语“producing a series of actions, one for each time step △t”为结果状语，说明优化成本函数后产生的结果。因嵌套的限定性定语从句修饰“lateral control”，而整个定语从句修饰限定主语 MPC。核心句中的谓语、宾语较短，如果非限制性定语从句也使用前置法翻译，会导致译文 1 中主语过长，不利于流畅地阅读。译文 2 采用综合法翻译，将“which manages the lateral control that provides the engineering signal”这个定语从句采用前置法单独译成了一个分句，而全句基本采用顺译法进行翻译，并分译成了几个分句。整个句子读起来逻辑清晰，便于读者对复杂概念的理解。

3.2.2 含状语从句的长难句的翻译

状语从句根据其功能可以分为九类，即时间、地点、结果、时间、目的、让步、条件、方式和原因（Quirk, R. et al, 1985: 213）。状语从句功能较多、位置灵活，如何选择合适的翻译方法，便于读者阅读、理解，是本次翻译实践的难点之一。

3.2.2.1 逆序法

英语中，部分长句的表达顺序与汉语不同或者完全相反，英译汉时，无需参考原句的次序，从句尾开始翻译（张培基，2009：186）。中英文在表达顺序上有很大的不同，中文一般重视时间先后，因果顺序等，在英语状语从句表达的语序和中文相反时，必须符合译入语的表达习惯，采用逆序法进行翻译。

例 12：AVs do have the ability to replace humans in the bulk of traffic incidents if the technique is capable of living up to its words; nevertheless, they must initially depend on automated driving vehicles that can perceive better than the greatest human driver on the roadway.

译文 1：自动驾驶汽车确实有能力在大部分交通中取代人类，如果这项技术能够达到预期。然而，它们最初必须依赖那些感知能力比道路上最优秀的人类驾驶员还要强的自动驾驶汽车。

译文 2：如果这项技术能够达到预期，自动驾驶汽车确实有能力在大部分交通中取代人类。然而，它们最初必须依赖那些感知能力比道路上最优秀的人类驾驶员还要强的自动驾驶汽车。

分析：该句为主从复合句，由主句“AVs do have the ability to replace humans in the bulk of traffic incidents”，条件状语从句“if the technique is capable of living up to its words”，定语从句“that can perceive better than the greatest human driver on the roadway”组成。译文 1 采用顺译法处理条件状语从句，结果在前，条件在后，不符合中文的表达习惯，重点不够突出。译文 2 采用逆序法，按照中文“先因后果”的逻辑进行翻译。先描述条件，再讲述带来的结果，逻辑更加清晰，便于读者阅读。

例 13：Nevertheless, confidence for 5G-enabled AI-powered automated driving technology is on the rise as advances in partially automated vehicles provide a realistic view of what the following decade may involve.

译文 1：然而，人们对 5G 和人工智能驱动的自动驾驶技术的信心正在上升，是因为部分自动驾驶车辆的进步为未来十年可能的涉及的情况提供了现实展望。

译文 2：尽管如此，因为部分自动驾驶汽车的进步为未来十年的发展提供了预期，所以人们对 5G 赋能、人工智能驱动的自动驾驶技术的信心正在上升。

分析：该句为主从复合句，由主句“confidence for 5G-enabled AI-powered automated driving technology is on the rise”和原因状语从句“as advances in partially automated vehicles provide a realistic view of what the following decade may involve”组成，通过连接词“as”表明主句情况发生的原因。译文 1 采用顺序法进行翻译，虽译出原因状

语从句的“因为”，但在句子后面，不符合中文表达习惯。由于中文习惯先因后果，故译文 2 选择逆序法进行翻译，在捋清原文逻辑顺序的基础上，加上逻辑词“因为……所以……”。为了使译文更加流畅，译文 2 将“what the following decade may involve”的本意“未来十年可能涉及的情况”理解为自动驾驶技术在各个方面的发展，从而引申为“未来十年可能的发展”，便于读者接受。

3.2.2.2 转换法

转换法是一种处理状语从句的实用技巧，其核心在于突破表层语法结构的限制，通过语义逻辑的深层转换实现跨语言的精准表达。在翻译中，过于局限于某些连接词的本意，会导致翻译出来的语句生硬、晦涩，此时若选择转换法，赋予连接词更加贴合原文的含义，可让译文更加生动、流畅。

例 14：Because of the way it is built, it is very resilient in the sense that it functions well when a large diversity of data types is created by a large number of network neighbors.

译文 1：由于其建构方式，在处理大量网络邻居创建的各种数据类型时运行良好，富有弹性。

译文 2：如果它的架构方式如此，该系统就具有显著的弹性。在大量网络邻居生成多种数据类型的情况下，它仍能良好运行。

分析：该句为主从复合句，主句为“it is very resilient in the sense that it functions well”，其中“that it functions well”为同位语从句；“when a large diversity of data types is created by a large number of network neighbors”是时间状语从句，修饰动词“function”。

译文 1 将“when a large diversity of data types is created by a large number of network neighbors”直接译为时间状语，同时对原文的部分内容进行了整合，但逻辑关系不够突出，没有明确体现出“建构方式、运行良好、富有弹性”之间的因果关联，以及“处理大量网络邻居创建的各种数据类型、富有弹性”的内在联系，读者难以理清其中的逻辑脉络。译文 2 考虑到“when a large diversity of data types is created by a large number of network neighbors”这个形式上的时间状语从句，时间意味并不明显，实际上它是一个条件，将其转换为条件状语“在……的情况下”，这样就清晰地展现了该架构方式运行良好的条件。同时，译文 2 还采用了分译法，将一个英语长句分译成了两个分句，逻辑更加清晰。

例 15：LiDAR-Based Obstacle Detection: Contrary to commercial LiDAR, the simulated sensor provides neither intensity nor ring data because it is a ray-casting approach.

译文 1：基于激光雷达的障碍物检测：与商业激光雷达相反，该模拟传感器既不提供强度数据也不提供环数据，因为它是一种线性投射的方法。

译文 2：基于激光雷达的障碍物检测：与商业激光雷达相反，该模拟传感器采用光线投射的方式，既不提供强度数据也不提供环数据。

分析：该句为主从复合句，“LiDAR-Based Obstacle Detection”是主体部分，点明该句讨论的核心内容是基于激光雷达的障碍物检测。“the simulated sensor provides neither intensity nor ring data”是句子的主干部分，说明模拟传感器的情况，“because it is a ray-casting approach”是原因状语从句，解释模拟传感器不提供强度数据和环数据的原因。译文 1 通过顺译法进行翻译，在中文中先果后因的顺序连贯性不强；同时译文 1 的顺序将模拟传感器定义为一种方法，译文读起来晦涩难懂。译文 2 将原因状语从句转换为方式状语从句，先指明传感器工作的方式，随后强调其带来的结果“既不提供强度数据也不提供环数据”，突出了方式对结果的决定性作用，便于读者阅读。

3.3 译文语意连贯的再现

信息型文本以交际性为主，要以读者的阅读感受为首要任务，译文语意连贯的再现又是此次翻译实践的难点之一。衔接（cohesion）通过词汇或语法手段使文脉相通，形成有形网络；而连贯（coherence）是指以对话双方共同了解的情景为基础，通过推理达到语义的连贯，构成篇章的无形网络（李静，2012：39）。缺乏连贯性，会给文章阅读造成困难，严重的导致表意不清，甚至语无伦次（蔡力坚，2024：189）。在源文本中，主要涉及两个方面：一是上下文指代多，在翻译成汉语时常需指出指代的内容是什么，即回指的明示；二是有些句子结构，如果直译出来，显得表达不够充分，需要译者根据英文上下文的理解进行补充说明，以符合汉语逻辑，即语义的增译。

3.3.1 回指的明示

回指最早起源于古希腊语，意为“再次携带”，原是一种修辞手法，指在句子中多次重复使用词汇或短语，表达特定语气，起突出强调的作用。通常，回指是指在后续语篇中引用前文已提到的实体。在同一段落甚至同一语句的语篇指称语境中，并非总是选择使用相应的代词回指表达形式，而绝大部分使用与先行词相同的名词回指

转述指称形式（刘彩霞，2020：134）。为避免读者阅读时的误解，我们要将代词所指明示出来。

例 16：However, they both require the same extremely accurate calibration as well as their operative range (often under 20m) is constrained due to the strength of the emitter and the brightness of the surrounding light. Its performance can be impacted by reflections.

译文 1：然而，它们都需要相同的极其精确的校准，并且由于发射器的强度和周围光线的亮度，它们的工作范围（通常在 20 米以内）受到限制。其性能可能会受到反射的影响。

译文 2：但是，无论是结构光设备还是立体视觉系统，都需要非常精确的校准，并且它们的有效范围（通常在 20 米以内），受到发射器的强度以及周围光线亮度的限制，结构光设备的性能也会受到反射的影响。

分析：工程科技文本介绍专业术语较长的事物时，大量使用代词，介绍相同事物的段落中，可能只在句首提及专业名词，后面全篇用代词 they 或 it 指代。译文 1 大量使用代词“它”，会给读者阅读造成疑惑。本句话选自介绍 Structured light 的段落中：“Structured light: Monocular cameras attached to a system that casts a familiar pattern of infrared light over the scene. The camera picks an evident distortion of the light pattern caused due to irregular surfaces and is converted into a depth map. Due to the fact that they are less expensive to compute and do not rely on textured surfaces, structured light devices are able to circumvent some of the drawbacks of stereoscopic systems.（结构光：连接到系统上的单目相机，该系统可以在场景上投射一种熟悉的红外光模式。相机捕捉到由不规则表面引起的光图案明显畸变，并将其转化为深度图。结构光设备的计算成本较低且不依赖纹理表面，能够规避立体视觉系统的某些缺点。）”原文段落使用代词“they”，结尾却用单数形式“its”，很容易让人产生歧义，不知介绍的优点是属于结构光设备还是立体视觉系统。此时，必须进行代词回指的明示，将指代的名词重复提及，避免迷惑、歧义。根据上文，译文 2 把“they”明示为“结构光设备还是立体视觉系统”，“its”重点突出“结构光设备”，这样可以有效避免读者阅读障碍。

例 17：According to the study, since there are effective cellular or LTE communication channels between roadside devices and the cloud platform, radio frequency identification should be used by moving cars and roadside units for vehicle-to-infrastructure communication. According to the study, it will have a huge impact on the healthcare industry and can also be utilized for vehicle-to-vehicle communication.

译文 1：研究显示，鉴于路边设备与云平台之间存在有效的蜂窝或长期演进（LTE）通信信道，移动车辆和路边单元应采用射频识别技术进行车与基础设施之间的通信。研究显示，它将对医疗保健行业产生巨大影响，还可用于车对车通信。

译文 2：研究显示，鉴于路边设备与云平台之间存在有效的蜂窝或长期演进（LTE）通信信道，移动车辆和路边单元应采用射频识别技术进行车与基础设施之间的通信。研究显示，射频识别技术将对医疗保健行业产生巨大影响，还可用于车对车通信。

分析：源文本多技术、多概念交杂，很难靠代词快速判断具体所指。句中的“it”指代前文提及的“radio frequency identification（射频识别技术）”，但由于句子内容丰富，信息量大，且前文出现了多个技术相关名词，如“vehicle-to-vehicle communication（车对车通信）、cellular or LTE communication channels（蜂窝或 LTE 通信信道）”等，使得“it”的指代关系不那么一目了然，增加了理解难度。译文 2 将“it”所指明确翻译出，便于读者理解。

3.3.2 语义的增译

逻辑思维能力是指译者能够抓住作者的思路，理解原文的思想，包括发现文章与外部世界的联系、文章前后的关联、各种衔接关系、从属关系和同义关系，还包括能够在译文中再现原文的逻辑（李长栓，2021：76）。在不改变原文基本意义的前提下，有意识地增加一些词语、短语、句子或其他语言成分，以使译文在语意上更加完整、清晰、准确，更符合目标语的表达规范，更易于读者理解原文所传达的信息和意图。科技文本无论是英汉哪种语言，都比一般的人际交流文本和文学文本表达更严谨，其表达都会加强界限，使用更多的界限标记，尽量少给读者想象空间，避免造成歧义，从而带来意料之外的风险或损失（吴碧宇、王建国，2025：18）。

例 18：Speed observation can aid to increase activity recognition and behavior prediction in addition to target-tracking abilities, for example by detecting the different speeds of a cyclists and a pedestrian’s body parts.

译文 1：除了目标跟踪的功能外，观测速度可以帮助增强活动识别和行为预测的能力。例如，通过检测骑车者和行人身体部位的不同速度。

译文 2：除了目标跟踪的功能外，观测速度可以帮助提高活动识别和行为预测能力。例如，通过检测骑车者和行人身体部位的不同速度，用来预判他们的行动。

分析：该句属于主谓宾结构，可将 in addition to 引导的宾语提前，重点突出

“activity recognition”以及“behavior prediction”这两个功能。同时，后面紧跟介词短语作方式状语，具体说明如何帮助提升的。如只按照译文 1，会让读者感觉举例的话没说完。译文 2 通过增译目的状语“用来判别他们的行动”，让原文中隐含的逻辑目的以文字的形式呈现，逻辑更加连贯，读起来更加完整，便于读者理解。

例 19：Autonomous cars should be capable of driving in all meteorological states. No room for mistakes or shutdowns.

译文 1：自动驾驶汽车应该能在各种气象条件下驾驶。不能出错或停止运行。

译文 2：自动驾驶汽车应该能够在所有气象条件下行驶。这就意味着在任何情况下，都不能出错或停止运行。

分析：原句由两句话构成，“Autonomous cars should be capable of driving in all meteorological states”，明确提出自动驾驶汽车需要具备在各种气象条件下行驶的能力，这是对自动驾驶汽车性能的一种要求设定。“No room for mistakes or shutdowns”，则进一步强调在这种行驶过程中的限制条件，即不能出现错误或停止运行的情况。两句话之间存在着隐含的因果逻辑关系，因为要在所有气象条件下行驶，所以不允许出错或停止运行，后一句是对前一句的补充说明和进一步约束，并不是毫无关系的两句话。译文 1 单独翻译两句话，没有体现原文的隐含逻辑，需要读者去自行理解和建立两句话之间的联系。译文 2 添加了“这就意味着在任何情况下”，将两句话之间隐含的因果逻辑关系显化出来，清晰地表明了后一句是对前一句的进一步阐释，让读者能够更轻松地理解为什么自动驾驶汽车不能出错或停止运行，是因为它需要在所有气象条件下行驶这一前提条件。

第四章 总结与反思

4.1 译文质量提升

审校是翻译全过程的一个重要环节，是确保译文质量的最后关口。在翻译流程里，审校的重要性不容忽视，其对于提升译文的准确性、流畅性以及专业性起着决定性作用。

在自我审查阶段，译者秉持严谨认真的态度，逐字逐句地将译文与原文进行细致对照，仔细核查译文中是否存在错译、漏译的情况。完成初步的核查之后，译者需要再次对译文进行精读。此次精读的重点在于关注语句的通顺度和自然度，仔细甄别译文中是否存在晦涩难懂的表述，以及逻辑表达是否连贯清晰。译者需要对译文的遣词造句进行反复斟酌，对句子结构进行合理调整，以提升译文的可读性和流畅性。译者要通过这次审读，判断译文是否能够让缺乏专业背景知识的普通读者轻松流畅地阅读，内容是否易于理解和接受。如果发现译文存在理解困难或者表述生硬的地方，译者需要及时进行修改和完善。

同时，译者寻求了 5 名同翻译专业方向的同学帮忙审校。同学们在阅读译文时，将发现的逻辑混乱、理解困难的部分标记出来，每人针对译文提出 3 条以上的建议。这些标记和建议帮助译者更有针对性地对译文进行改进。随后，译者和同学们对标记出的理解错误的地方展开深入探讨和分析。双方充分交流各自的理解和看法，重新对这些部分进行翻译，提高译文的准确性和专业性。在遇到专业性较强的问题时，及时地向相关专业的老师寻求帮助。根据老师的建议对译文进行调整和优化，确保译文中的专业内容准确无误。

最后，译者邀请导师对译文进行指导。针对自我审校和同学审校后遗留的问题，译者向导师请教，认真倾听导师的指导和修改建议。同时，导师以专业人士的角度阅读译文，检查译文的逻辑脉络、各个部分之间的逻辑关系是否紧密、合理，是否能够清晰地传达原文的核心思想，检查译文的流畅度。同时，检查译文中词汇的选择是否准确恰当，符合原文的风格和语境，以及汉语的阅读习惯。译者根据导师的建议，对译文进行了全面的优化，对逻辑结构进行调整，对词汇进行替换或补充，对语句进行润色和完善。最终确定出准确、流畅的译本，完成翻译任务的终稿。这样的终稿不仅能够准确传达原文的内容，还在语言表达、逻辑结构和专业术语使用等方面能够满足

读者的阅读需求，实现翻译的目的。

4.2 主要收获

在本次《自动驾驶汽车的人工智能》第四章的翻译实践中，译者收获颇丰，这些收获不仅深化了对翻译工作的理解，也能为他人在类似翻译工作中提供有益的借鉴。

从半技术词汇的翻译案例来看，通过对专业领域知识的深入钻研以及对平行文本的广泛查阅，译者深刻认识到准确把握词汇在特定语境中含义的重要性。翻译信息型文本时，译者必须具备跨领域知识储备，不能仅仅依赖常规词典释义；要深入挖掘专业知识，广泛搜集平行文本，精准界定词汇意义，避免望文生义导致的翻译偏差。

在长难句翻译方面，通过运用前置法、分译法、综合法等技巧处理含有定语从句的长难句，以及逆序法、转换法等应对含有状语从句的长难句，译者发现对句子结构的精准分析是翻译的基础。译者需熟练掌握各类语法知识，灵活运用翻译技巧，将长难句化繁为简。在面对长难句时，不要畏惧，要冷静分析句子结构，尽力理解原文表达目的，根据不同从句类型选择合适的翻译方法，确保译文忠实于原文逻辑且符合目标语言表达习惯。

在实现译文语义连贯的过程中，语义增译和回指的明示起到了关键作用。通过合理增译原文隐含信息，明确回指代词所指代的对象，译文的逻辑性和可读性大幅提升。译者不能局限于字面翻译，要充分考虑读者的理解需求。翻译时要时刻以读者为中心，思考如何通过适当的手段使译文在语义上连贯流畅，让读者能够轻松理解原文复杂的技术内容。

总的来说，本次翻译实践让译者明白，信息型文本翻译需要译者具备扎实的语言功底、丰富的专业知识、熟练的翻译技巧以及强烈的读者意识。这些经验或体会，希望能为从事相关翻译工作的人员提供参考，助力他们在翻译工程科技类文本时少走弯路，提高翻译质量。

4.3 不足与改进

在翻译自动驾驶汽车相关信息型文本时，译者发现自身存在一些不足，需要采取相应措施加以改进。

在查证和网络运用能力方面，信息型文本中充斥着大量专业术语，给翻译工作带来诸多挑战。尽管译者借助各类学术网站查阅了大量学术著作和期刊论文，也利用维

基百科对部分术语进行了解释，但仍有个别术语难以查到。这反映出译者在专业术语学习和研究上的不足，以及网络检索能力有待提高。为解决这些问题，译者将主动深入学习自动驾驶汽车领域的专业术语，系统研究其构词规律和行业背景知识。同时，不断提升网络检索技巧，拓宽信息搜索渠道，学习利用专业数据库和行业论坛获取信息。此外，积极与该领域的专家交流，虚心向他们请教专业知识，以弥补自身在术语查证方面的短板。

在翻译效率和方法上，由于译者初次接触汽车领域知识，专业背景知识匮乏，导致对部分术语和零件难以理解，过度依赖直译，使得译文不够流畅，翻译效率也大打折扣。为改进这一状况，译者会注重不同领域知识的积累，广泛阅读汽车行业相关资料，建立起扎实的知识储备。同时，深入研究目标语言的表达习惯，在翻译时灵活调整语序和用词，使译文更符合目标语言的表达逻辑。另外，克服自身的惰性，加强对译文的反复阅读和修改，从读者的角度审视译文，确保译文流畅自然、可读性强。通过这些努力，不断提升自己的翻译水平，更好地完成各类翻译任务。

参考文献

Newmark, P. *A Textbook of Translation*. Shanghai: Shanghai Foreign Language Education Press, 2001.

Quirk, R. et al. *A Comprehensive Grammar of the English Language*. Longman House, Burnt Mill Harlow, England, 1985.

Sathiyaraj, R. et al. *Artificial Intelligence for Autonomous Vehicles*. Scrivener Publishing, Hoboken, America, 2024.

蔡力坚："科技类文本的翻译探析"，《中国翻译》，2023 年第 6 期，第 154-157 页。

蔡力坚："论连贯的重要性"，《中国翻译》，2024 年第 2 期，第 182-185 页。

方梦之：《英语科技文体：范式与翻译》，北京：国防工业出版社，2011。

方梦之："应用(文体)翻译学的内部体系"，《上海翻译》，2014 年第 2 期，第 1-6 页。

高巍、孙凤兰："科技语篇的隐喻功能与翻译——以《时间简史》英汉文本为例"，《上海翻译》，2020 年第 3 期，第 29-33+89 页。

何三宁："寻找美的线条——科技翻译策略的一个新视角"，《上海翻译》，2011 年第 3 期，第 29-32 页。

孔德亮："机电工程英语的特点及翻译"，《中国科技翻译》，2013 年第 4 期，第 5-7+27 页。

李长栓："以实践报告展示翻译能力--论翻译硕士专业学位研究生翻译实践报告的写作"，《中国翻译》，2021 年第 2 期，第 72-79 页。

李长栓："以'信达切'融通中外翻译理论与实践"，《上海翻译》，2025 年第 1 期，第 13-18 页。

刘彩霞："新闻报道语篇同名回指转述的语用认知阐释"，《天津外国语大学学报》, 2020 年第 3 期，第 126-135+160 页。

李静："语篇连贯与翻译策略"，《上海翻译》，2012 年第 4 期，第 39-42 页。

李帅、孙成杰："海事英语汉译技巧例析"，《中国水运》，2016 年第 11 期，第 72-75 页。

秦艳霞、刘德连："术语'智能网联汽车'的英译名探析"，《中国科技翻译》，2024 年第 4 期，第 58-61+46 页。

吴碧宇、王建国:“英汉科技翻译的扩展技巧”,《中国科技翻译》,2025 年第 1 期,第 17-20 页。

韦孟芬:“浅析科技英语翻译的词义选择”,《中国科技翻译》,2015 年第 1 期,第 1-3+35 页。

于建平:“科技英语长句的分析及翻译”,《中国科技翻译》,2000 年第 3 期,第 14-16 页。

袁瑛:“生物专业英语定语从句的翻译技巧”,《中国科技翻译》,2010 年第 1 期,第 6-8 页。

张必胜:“华蘅芳科技翻译之思想史意义探析”,《上海翻译》,2023 年第 3 期,第 70-75 页。

张培基:《英汉翻译教程》,上海:上海外语教育出版社,2009。

附录 1：术语及专有名词表

序号	英文	中文
1	3D point cloud	三维点云
2	3-Dimensional Technology	三维技术
3	accelerator	加速器
4	active sensing	主动传感
5	adaptive actions	自适应驾驶动作
6	ADAS (advanced driver assistance systems)	高级驾驶辅助系统
7	airbags	安全气囊
8	anti-lock braking system	防抱死制动系统
9	artificial intelligence	人工智能
10	Artificial Vision	人工视觉
11	autonomous learning	自主学习
12	autonomous navigation	自主导航
13	AV (Autonomous Vehicle)	自动驾驶汽车
14	Avalanche photodiodes	雪崩光电二极管
15	binary collision prediction	二元碰撞预测
16	binary creeks	二进制数据传输流
17	blind spot detection (BSD)	盲点检测
18	brake pedal motor	制动踏板电机
19	CAN Bus (Controller Area Network)	控制器局域网总线
20	capturing spectrum	采集光谱
21	Cartesian coordinate system	笛卡尔坐标系
22	cell load balancing	电池单元负载平衡
23	charge-coupled devices (CCD)	电荷耦合器件
24	charging management	电池充电管理
25	chassis	底盘
26	Coherent Network Data	协同网络数据
27	complementary metal oxide semiconductors	互补金属氧化物半导体
28	convolutional neural network	卷积神经网络

29	Deep learning (DL)	深度学习
30	delay minimization	最小化延迟
31	deliberate control	审慎控制
32	distortion	畸变
33	DoD (Department of Defense)	美国国防部
34	Doppler effect	多普勒效应
35	Doppler shift variation	多普勒频移变化量
36	echo	回波
37	emitted wave	发射波
38	emitter	发射器
39	event-based vision	事件驱动视觉
40	far-infrared (FIR)	远红外
41	FoV	视场
42	frame rate	帧率
43	gear system	齿轮系统
44	Global Navigation Satellite System (GNSS)	全球导航定位系统
45	GPS	全球定位系统
46	hardware abstraction layer (HAL)	硬件抽象层
47	Hardware Architecture	硬件架构
48	HVAC	暖通空调
49	Hazardous Obstacle Monitor	危险障碍物监测
50	high-dynamic range (HDR)	高动态范围
51	highly autonomous vehicle (HAV)	高度自主驾驶汽车
52	hybrid propulsion systems	混合动力系统
53	indirect time-of-flight	间接飞行时间法
54	induction loops	感应线圈
55	Industrial Personal Computers (IPCs)	工业用个人计算机
56	Inertial Measuring Units	惯性测量单元
57	Internet of Vehicle（IoV)	车联网
58	IoT	物联网
59	ITS	智能交通系统

60	laser light pulses	激光脉冲
61	latency	时延
62	LED	发光二极管
63	LiDARs（Light Detection and Ranging）	激光雷达（激光探测和测距）
64	Light polarization sensors	光偏振传感器
65	linear algebra	线性代数
66	Long-Term Evolution (LTE)	长期演进
67	Machine learning (ML)	机器学习
68	magneto-resistive tissue	磁阻元件
69	Manual Balance	手动平衡
70	Markov decision processes (MDP)	马尔可夫决策过程
71	mask	蒙版
72	medium Earth orbit (MEO)	中地球轨道
73	meta-material	超材料
74	Microscopic Traffic Simulator	微观交通模拟器
75	model-based predictive control (MPC)	基于模型的预测控制
76	monocular cameras	单目相机
77	near-infrared (NIR)	近红外
78	net amount	净额
79	network peers	网络对等体
80	Object Finder	物体检测器
81	object separation	目标分离
82	Obstacle Detection	障碍物检测
83	optical phased array (OPA)	光学相控阵
84	optical recognition systems	光学识别系统
85	pan-tilt-zoom image sensor	云台变焦图像传感器
86	Petabytes	拍字节
87	phase	相位
88	phased array radars	相控阵雷达
89	pixels	像素

90	proprioceptive pseudo sensor	本体感受伪传感器
91	pulsed light time-of-flight	脉冲光飞行时间
92	QoS	服务质量
93	Radar Interference	雷达干扰
94	Radio Detection and Ranging	无线电探测和测距
95	range resolution	测距分辨率
96	reactive command	反应性指令
97	real-time kinetics	实时动力学
98	remote control intervention	远程控制干预
99	resolution	分辨率
100	retina	视网膜
101	ring compression	环压缩
102	risk assessment	风险评估
103	road backups	道路拥堵
104	Robotics Simulator	机器人仿真器
105	ROS (Robot Operating System)	机器人操作系统
106	routing algorithm	路由算法
107	seat belt pretensioners	安全带预紧器
108	smart cities and IoTs	智慧城市和物联网
109	Society of Automotive Engineers (SAE)	汽车工程师协会
110	solid-state oscillating micro mirror	固态振荡微镜
111	spectra	光谱
112	stationary impediments	静止障碍物
113	steering wheel motor	方向盘电机
114	Stereo Vision	立体视觉
115	Stereoscopic systems	立体视觉系统
116	Structured light	结构光
117	sub-microsecond timescales	亚微秒级
118	synthetic aperture radars	合成孔径雷达
119	target categorization	目标分类
120	target tracking	目标跟踪

121	the National Highway Traffic Safety Administration in the United States	美国国家公路交通安全管理局
122	throughput maximization	最大化吞吐量
123	time stamp	时间戳
124	trajectory identification	轨迹识别
125	triggered asynchronously	异步触发
126	ultrasonic sensor	超声波传感器
127	Unknown Obstacles Recognition (UOR)	未知障碍识别
128	user datagram protocol	用户数据报协议
129	V2X	车辆与万物互联
130	VANETs	车辆自组织网络
131	vector machine	支持向量机
132	Vehicle Positioning and Localization (VPL)	车辆定位
133	Vehicle-mounted computing platform	车载计算平台
134	vehicular sensor networks (VSNs)	车载传感器网络
135	virtual scanning	虚拟扫描
136	Virtual Server for Data Transmission	数据传输虚拟服务器
137	virtual switch	虚拟交换机
138	visual odometry	视觉里程计

附录 2：原文与译文

原文	译文
4. A Survey on Architecture of Autonomous Vehicles	第四章 自动驾驶汽车框架综述
Abstract	摘要
Artificial intelligence is now a necessary component for both production and service systems in recent years, as technology has become a vital aspect of daily life. Automated driving vehicles operate autonomously, also known as driverless cars that can operate without a human driver.	近年来，人工智能成为生产和服务系统的必要组成部分，因为技术已成为日常生活的一个重要方面。自动驾驶汽车可以自动驾驶，也称为无人驾驶汽车，无需驾驶员即可运行。
Research on autonomous vehicles has substantially advanced in recent years. Artificially intelligent autonomous vehicles are the current need of the society. Although some people might be apprehensive to give a computer control of their vehicle, automated driving technologies have the potential to make roads safer. Self-driving automobiles can address environmental issues as well as safety-related ones.	近年来关于自动驾驶汽车的研究取得重大进展。人工智能自动驾驶汽车是当今社会所需的。尽管人们对于计算机驾驶汽车表示担忧，但自动驾驶汽车有可能使道路更安全。自动驾驶汽车既可以解决环境问题，也可以解决与安全相关的问题。
Unlike humans, computers do not really have difficulty keeping attention when driving. Additionally, by responding	与人类不同，计算机在驾驶时更易保持注意力。此外，通过适当响应，自动驾驶汽车可以防止道路上发生

appropriately, an automated car can prevent accidents to potentially dangerous events on the road. Self-driving technology has many advantages, one of which will make more easily accessible means of transport to people who are unable to drive.	潜在危险事件引发的事故。自动驾驶技术有很多优点，其中之一是使无法驾驶汽车的人群更容易获得交通工具。
For a variety of reasons, such as inexperience, incapacity, or age, many people are unable to operate a vehicle. These individuals can travel considerably more safely and independently. Therefore, we will explore the architectures of both software and hardware of autonomous cars in this chapter, as well as their parts, benefits, and future developments.	由于各种原因，如缺乏经验、无行为能力或年龄限制，许多人无法驾驶车辆。为了让这些人更独立、更安全的旅行。因此，本章我们将探讨自动驾驶汽车的软件和硬件架构，以及它们的组成部分、优势、未来发展。
Keywords: Autonomous vehicles, artificial intelligence, radar, LiDAR, GPS, CAN bus, GNSS	**关键词**：自动驾驶汽车、人工智能、雷达、激光雷达、GPS、 CAN 总线，GNSS
4.1 Introduction	4.1 简介
4.1.1 What is Artificial Intelligence?	4.1.1 什么是人工智能？
Unlike the intelligence possessed naturally by both humans and animals, the knowledge demonstrated by machines is called artificial intelligence (AI). <u>An investigation of intelligent agents that perceive their environments that react in a manner that maximizes their success</u>	与人类和动物自然拥有的智慧不同，机器展示的知识被称为人工智能（AI）。<u>能够感知自身所处环境的智能主体，其感知方式可以使自身成功的几率最大化。对于这样的智能主体的研究，可能被视为人工智能研究。</u>

chances might be characterized as AI research [1].	
Before, AI was called to be mimicking and exhibiting human cognitive capabilities that are linked to the human brain. This was rejected by many AI researchers, and all are now reexpressing artificial intelligence in a way of acting rationally [2].	在此之前，AI 用于模仿并展示与人脑相关的人类认知能力。这被许多 AI 研究人员抵制，现在他们都在以理性的方式重新表达人工智能。
Innovative Web search engines like Google, engines recommending as YouTube, Amazon, and Netflix, speech-recognition mechanisms like Siri, cars like Tesla that can drive on its own, decisions that are automated and overpowering the top games that use strategies. Artificial intelligence impact is an event where the capability of tools is more, moves that were once thought to need intelligence are now frequently excluded as more competent according to the concept of AI.	以谷歌为例的创新网络搜索引擎，以优兔，亚马逊、奈飞为例的推荐引擎，像 Siri 这样的语音识别机制，像特斯拉这样可自动驾驶、自动化决策的汽车，其已超越使用策略的顶级游戏。人工智能的影响体现为工具能力增强。那些曾被认定需要智能才能完成的动作，随着人工智能的概念的演变，如今常常不再需要了。
Despite being a prevalent technology, optical recognition systems are commonly excluded from the list of things that are considered to be AI [3]. While talking about AI, supercomputers are the things that we get remembered of. A supercomputer has huge processing power,	尽管光学识别系统是一种流行的技术，但它通常被排除在被认为是人工智能的事物列表中。每每谈及 AI，超级计算机都是被我们记住的东西。超级计算机拥有强大的处理能力，自适应驾驶动作（通过传感器），这些能力有助于融合人类理解和功

adaptive actions (via sensors), and a variety of many abilities that help it to incorporate human's understanding as well as functional capacity, which actually helps in enhancing the communication of the supercomputer with humans.	能能力，实际上增强了超级计算器与人类的通信。
In fact, a variety of films had been produced in order to demonstrate the capabilities of AI, which includes smart buildings, like the ability of it to control temperatures, quality of air, and music depending on the detected feel of the residents of the place. Apart from the formal understanding of AI as well as a supercomputer to encompass integrated computer systems, there has been a growth in the use of AI within the education sector [4].	实际上，为了展示人工智能的能力，现已制作了各种电影，其中包括通过检测居住地居民的感受而自动控制温度、空气质量以及播放音乐的智能建筑。除了对 AI 正式的理解以及包含集成计算机系统的超级计算机外，AI 在教育领域的使用也有所增长。
The ability of reasoning as well as taking actions that have the best likelihood to reach a certain objective is the ideal quality of AI. Machine learning (ML), being a subtype of AI, is a way in which computer programs automate learning from previous data and adapt themselves to new data, and these are done without human intervention. Deep learning (DL) is again a subtype of ML and these	正确推理并采取行动，最有可能达到特定目标的能力，这是人工智能的理想目标。机器学习（ML）是 AI 的一个子类型，是计算机程序自动从旧数据中学习，并适应新数据的一种方式，这些无需人工干预即可完成。深度学习（DL）也是机器学习的一个子类型，这些算法通过输入大量的非结构化数据（如文本、图像以及视频）来帮助自主学习。

algorithms help in autonomous learning by feeding mass quantities of unstructured data, like text, photos, and video.	
AI was developed with the goal of explaining human intelligence in a way that would make it simple for a machine to replicate it and perform challenging tasks. AI's goal is to mimic human cognitive functions. When it comes to specifically characterizing various processes like learning, thinking, and perception, academics have made great strides in this area. Few ideas are emerging that new systems will be created that are much better than learning and understanding of humans. But still, few are standing on the point that cognitive processes involve value judgment and these come from human experience. Others, however, continue to hold this view, since value judgments are a part of all cognitive processes and are influenced by human experience [5].	AI以解释人类智能为开发目标，让机器能够轻松地复制人类智能并完成挑战性的任务。AI 以模仿人类认知功能为目标。在具体描述学习、思考以及感知等过程方面，学术界已取得长足进步。很少有想法表明会创建比人类学习和理解能力更强的新系统。但是，也很少有人认为认知过程涉及价值判断，而这些判断来自于人类的经验。然而，其他人仍然持有这一观点，因为价值判断是所有认知过程的一部分，并受人类经验影响。
4.1.2 What are Autonomous Vehicles?	4.1.2 什么是自动驾驶汽车？
In a self-driving car, a variety of in-car technologies like sensors, GPS, anti-lock braking system, and radars are used [6]. The sensing capability of its	在自动驾驶汽车中，使用传感器、全球定位系统（GPS）、防抱死制动系统以及雷达等车载技术。汽车周围环境的感知能力使自动驾驶汽车

surroundings enables an autonomous vehicle (AV) to drive by itself and carry out analytical tasks without the intervention of a human. To respond to the environment like a human driver, AVs use a complete automated driving system [7].	（AV）能够在没有人类干预的情况下自动行驶并执行分析任务。为了像人类驾驶员一样的响应环境，自动驾驶汽车使用了一套完整的自动驾驶系统。
Siegfried Marcus created the first vehicle in 1870.That was just a wagon that had an engine and did not have any steering wheel or brakes. The legs of the driver were used to control it. To convert conventional vehicles into autonomous ones, it nearly took more than one step. In 1898, the first initiative was taken. Operating the vehicle using a remote control was the prime idea behind it (Nikola,1898).	齐格弗里德·马库斯（Siegfried Marcus）于 1870 年发明了第一辆汽车。那只是一台有引擎，没有任何方向盘和刹车的马车，需要用司机的腿来控制。要将传统汽车转变为自动汽车，这个过程不止一步。1898 年，采取了第一个倡议，使用方向遥控器来操作汽车是其背后的主要思想（Nikola，1898）。
From this stage and because computers became sophisticated and powerful, contemporary automobile functions were transformed to automatic ones that did not even require remote control. The vehicles that were able to change gear without the driver’s assistance were named automatic automobiles (Anthony,1908), but today, there are vehicles that can travel completely on their own, despite the fact that in many places of	从这个阶段开始，随着计算器变得复杂和强大，现代汽车功能转变成甚至无需远程控制的自动功能。无需驾驶员控制就可换挡的车辆被称为自动汽车（Anthony，1908）。如今，有一些车辆可以完全自动行驶，但世界上很多地方仍旧不允许这类汽车在公路上行驶。这类汽车被称为“无人驾驶汽车”或“自动驾驶汽车”。

the world, they are still not allowed to drive on public roadways. These automobiles are referred to as “driverless cars” or “autonomous vehicles” [8].	
1. AVs are not systematically arranged despite this tendency. 2. Commercial vehicles shield their in-vehicle system interface from users, making it difficult for third parties to test new autonomous vehicle components. 3. Additionally, no two sensors are the same. Some cars might just use cameras, while others might mix cameras, milliwave radars, laser scanners, and GPS receivers [9].	1. 尽管存在这种趋势，但自动驾驶车辆（AVs）并没有得到系统化的安排。 2. 商用车辆的车载系统接口对用户进行屏蔽，使得第三方难以测试新的自动驾驶车辆组件。 3. 此外，没有两个传感器是相同的。有些汽车可能只使用摄像头，而另一些汽车会使用混合摄像头，毫米波雷达，激光扫描仪以及全球定位系统接收机。
4.2 A Study on Technologies Used in AV	4.2 自动驾驶汽车技术研究
All forms of autonomous cars need sensors because they can offer the information needed to comprehend the environment and, as a result, support decision-making. Sensors are essential parts of autonomous vehicles [24]. IoT is crucial to these cars. For example, connected cars are focusing on automation of internal functions of automobiles. These cars work by identifying the voice.	所有类型的自动驾驶汽车都需要传感器，因为传感器可提供理解环境所需的信息，从而支持决策。传感器是自动驾驶汽车必不可少的部件。物联网对这类汽车至关重要。例如，联网汽车专注于自动驾驶汽车内部功能的自动化。这些汽车通过识别声音来工作。
4.2.1 Artificial Vision	4.2.1 人工视觉

Popular technology known as artificial vision has been employed for years in fields like surveillance, industrial inspection, and mobile robotics. This technology has intriguing factors like affordable sensors for the most common types and a variety of information types like spatial, dynamic, and semantic (information about the meaning of words) (shape analysis). The industry offers a broad variety of camera configurations, including sensor size, frame rate, resolution (from less than 0.25 to more than 40Mpx), and optical specifications.	人工视觉这一广为人知的流行技术一直应用于监控、工业检测和移动机器人等领域。这项技术有一些有趣的因素，比如最常见类型的传感器价格实惠并且提供空间、动态和语义（关于词语含义的信息）（形状分析）等多种信息类型。该行业提供了各式各样的相机配置，包括传感器尺寸，帧率，分辨率（从小于 0.25 到超过 40 百万像素）以及光学规格。
4.2.2 Varying Light and Visibility Conditions	4.2.2 不同的光照和能见度条件
People can drive throughout the day or night. The application of dependable artificial visible algorithms is hampered by dark areas, shadows, glares, reflections, and other factors. Some of these issues can be resolved by expanding the capturing spectrum. Cameras with a far-infrared (FIR) range of 900-1,400nm are efficient for detecting animals and people in the dark, through smoke and dust. The visible spectrum is complemented by near infrared (NIR), which has a stronger	人们可在白天和晚上驾驶车辆。可靠的人工可见光算法的应用受到暗区域、阴影、眩光、反射等因素影响。其中一些问题可通过扩展采集光谱来解决。远红外（FIR）范围为 900-1400 纳米的相机可以有效地透过烟雾和灰尘，探测到黑夜中的人和动物。可见光光谱由近红外（NIR）补充，它在高动态范围（HDR）的环境中具有更强的对比度和更好的夜间能见度（750-900 纳米）。

contrast in settings with a high dynamic range (HDR) and better nighttime visibility (750-900nm) [10].	
4.2.3 Scenes with a High Dynamic Range (HDR)	4.2.3 高动态范围场景
In scenarios with a High Dynamic Range (HDR), such as when entering or exiting a tunnel, both dimly lit and brightly lighted areas can be visible in the same frame. Most sensor systems have single shot dynamic ranges between 60 and 75dB, which causes information loss at the extremes (under or over exposure). In 2017, Sony released a 120dB automotive sensor with 2K resolution in 2017. Analyses are performed using an HDR and NIR capable automotive grade sensor. When photographing sport scenes [11], a sensor with a 130/170dB range (global/rolling shutter configurations) is given, which offers a more thorough investigation of camera and sensor problems.	在高动态范围(HDR)场景中(例如汽车进出隧道时)，在同一帧（画面）中可同时呈现昏暗光照区和明亮光照区。大多数传感器系统的单发动态范围介于 60-75 分贝之间，这会导致在极端情况下（曝光不足或过曝）信息丢失。2017 年，索尼推出了一款 120 分贝、2000 分辨率的汽车传感器。使用 HDR 和 NIR 的汽车级传感器进行分析。拍摄运动场景时，使用一台 130/170 分贝（全局/卷帘快门配置）的传感器，可以更彻底地研究相机和传感器问题。
4.2.3.1 3-Dimensional Technology	4.2.3.1 三维技术
Although most vision sensors used in conventional cameras are 2 Dimensional, some of them are capable of sensing depth information. While not usually aimed at	尽管大多数相机中使用的都是二维视觉传感器，但其中有一些传感器可以感知深度信息。这些传感器通常不针对汽车市场，但本节重点介绍

the automotive market, this section highlights the three main types of currently available commercial devices.	了当前可用的三种主要商业设备类型。
·Stereo Vision: The evident movement of perceptible attributes of images taken by the two precisely calibrated monocular cameras pointed toward a similar direction and spaced apart results in the calculation of depth (known as baseline). The capacity of stereo vision systems to produce rich depth maps rather than sparse sensors is one of their major advantages (e.g., LiDARs). Low-textured patterns, such as solid colors, might make it harder to establish correspondences between frames, which is one of the limitations of stereo vision. <u>The functioning of a single monocular camera shifts an artificial baseline between subsequent frames, which is employed in monocular SLAM (simultaneous location and mapping) algorithms to evaluate depth and camera motion.</u> Numerous works present a good substitute for stereo sensors for positioning and mapping.	• 立体视觉：通过两个精确校准的单目相机拍摄的图像可感知属性的明显运动，这两个相机指向相似的方向并相距一定距离，从而计算出深度（称为基线）。立体视觉体系可以产生丰富的深度地图，而不是稀疏的传感器，这是立体视觉系统主要优势之一（例如：激光雷达）。如纯色等的低纹理图案，可能会使帧之间难以建立对应关系，这是立体视觉的局限性之一。<u>单个单目相机的运行会在后续各帧图像之间产生人工基线偏移，单目SLAM（同步定位和地图构建）算法中利用此偏移来评估深度和相机运动的情况。</u>许多研究作品都很好地代替了用于定位和地图构建的立体传感器。
·Structured light: Monocular cameras attached to a system that casts a familiar pattern of infrared light over the scene. The	• 结构光：连接到系统上的单目相机，该系统可以在场景上投射一种熟悉的红外光模式。相机捕捉到由不

camera picks an evident distortion of the light pattern caused due to irregular surfaces and is converted into a depth map. Due to the fact that they are less expensive to compute and do not rely on textured surfaces, structured light devices are able to circumvent some of the drawbacks of stereoscopic systems. However, they both require the same extremely accurate calibration as well as their operative range (often under 20m) is constrained due to the strength of the emitter and the brightness of the surrounding light. Its performance can be impacted by reflections.	规则表面引起的光图案明显畸变，并将其转化为深度图。结构光设备的计算成本较低且不依赖纹理表面，能够规避立体视觉系统的某些缺点。但是，无论是结构光设备还是立体视觉系统，都需要非常精确的校准，并且它们的有效范围(通常在20米以内)，受到发射器的强度以及周围光线亮度的限制，结构光设备的性能也会受到反射的影响。
·Time-of-flight: It is a form of active sensing that operates on the identical round-trip time theory that an infrared LED emitter floods the image with changed light, which, after being reflected by numerous things in the surroundings, is then captured by the sensor. The shift of phase of the approaching light that is converted to a distance can be used to determine the duration of each pixel's round-trip. In contrast to the lower divergence laser emitter used in LiDAR, using a non-directed light source has benefits such as capacity to produce high	• 飞行时间法是一种主动传感形式。其基于相同往返时间理论运行，即通过红外发光二极管（LED）发射器发出调制光来照亮图像。这种光被周围物体反射后，由传感器捕获。接近光的相位偏移可转换为距离，用来确定每个像素往返的持续时间。与激光雷达（LiDAR）使用的较低散度激光发射器相比，采用非定向光源更具益处（如能产生高刷新率（50赫兹以上）和精细的深度图）。同时，对于汽车应用而言，非定向光源的操作范围有限（10-20米），难以在光亮环境中运行。雪崩光电二极

refresh rate (above 50Hz) and detailed depth maps. For automobile applications, meanwhile, its operative range is limited (10-20m), and it struggles to operate in bright environments. Avalanche photodiodes, pulsed light time-of-flight, and indirect time-of-flight are some study areas that could extend operating in 50-250m in range.	管，脉冲光飞行时间，以及间接飞行时间法的操作范围在一些研究领域可扩展到 50-250 米。
4.2.3.2 Emerging Vision Technologies	4.2.3.2 新兴视觉技术
When the sensor elements (pixels) detect a change in light intensity, they are triggered asynchronously and independently in event-based vision. In order to create a picture that resembles a frame, the sensor generates a stream of events that can be divided into time frames. The sensor's dynamic range is increased to 120dB by its independent sensor parts, enabling high- speed applications in low light.	当传感器元素（像素）检测到光强度变化时，在事件驱动视觉中它们会异步独立触发。为了创建类似于帧的图像，传感器会生成可划分时间帧的事件流。传感器的独立传感器部分可将其动态范围增加到 120 分贝，从而在弱光环境下实现高速应用。
Despite the sensor's ability to operate at sub-microsecond timescales, it illustrates tracking at 1,000 FPS under typical indoor lighting conditions. Events could be used as an input for apps for visual odometry as well as SLAM, freeing CPU from laborious operations on raw	尽管传感器能够在亚微秒级的时间尺度下运行，其在典型室内光照条件下能以1000帧/秒的速度进行追踪。事件可通过视觉里程计以及 SLAM 应用程序输入，解放中央处理器（CPU）对原始照片的费力操作。光偏振传感器可在恶劣天气条件下

photographs. Light polarization sensors, which consistently function under challenging weather circumstances and provide unusual sorts of information, are the subject of active study.	持续工作，提供独特类型的信息，目前是热门的研究对象。
4.2.4 Radar	4.2.4 雷达
The round-trip time principle, refers to the amount of time that it takes for a wave to reach an item, bounce off of it, and then return to the sensor, is used by radar technology to calculate the distance to objects. The majority of contemporary car radars employ digital beamforming to regulate the direction of the radiated wave and are based on frequency-modulated continuous wave (FMCW) technology. A well-known stable signal with another continuous signal that modulates it with an up-and-down frequency variation is what makes up FMCW (typically using a triangular shape).	往返时间原理是指波到达一个物体，经过反射后返回到传感器所需的时间，雷达技术利用这样的原理来计算到物体的距离。现代汽车的雷达大多数采用数字波束成形技术来调节辐射波的方向，并基于调频连续波（FMCW）技术。一个稳定的已知信号与另一个连续信号相结合，后者通过上升和下降的频率变化来调制，这就构成了调频连续波（FMCW）（通常使用三角形形状）。
The difference in frequency between the emitted and reflected signals is used to calculate distance. Radars also use the Doppler effect to directly observe the targets relative speed in relation to the sensor. The independence of radar sensing from light and weather conditions is one of	发射信号和反射信号之间的频率差可用于计算距离。雷达还利用多普勒效应直接观察目标对于传感器的相对速度。雷达不受光线和天气情况影响，是将其纳入无人驾驶汽车最有说服力的理由之一。雷达可在黑暗中运行，并几乎能同样准确地探测到

the most compelling justifications for its inclusion in driverless vehicles. It operates in the dark and makes virtually equally accurate snow, rain, fog, or dust detections. In extremely challenging situations, where no other sensor can function, long-range radars will see 250m.	雪、雨、雾或灰尘。哪怕在极具挑战的情况下，没有其他传感器可以工作，远程雷达也可探测到 250 米的距离。
4.2.4.1 Emerging Radar Technologies	4.2.4.1 新兴雷达技术
High-resolution radar imaging for autos is one of the most active research fields. A greater resolution can obtain more semantic information and enable other applications like target categorization as well as environment mapping in addition to gains in target tracking and object separation [12]. A rotating radar of 90GHz is installed in the car roof and is used as an illustration for mapping the surrounding area, which includes cars, stationary objects, and the ground.	高分辨率汽车雷达成像是目前最热门的研究领域之一。除了提高目标跟踪和目标分离的效果外，更大的分辨率可以获得更多的语义信息，并能实现目标分类及环境地图绘制等其他应用。在车顶安装一个 90 千兆赫的旋转雷达，用于绘制包括车辆，静止物体和地面的周围环境示意图。
The purpose of this study is to demonstrate the practicality of radars operating between 100 and 300 GHz by analyzing the air absorption and reflectance of materials frequently seen in driving environments. High resolution radar imaging is made possible by meta-material based antennas for efficient	这项研究的目的是通过分析行车环境中常见材料的空气吸收和反射情况，来证明在 100 至 300 千兆赫频率范围内运行雷达的实用性。高分辨率雷达成像是通过基于超材料的天线实现的，这种天线用于高效的合成孔径雷达技术。基于这项技术，像

synthetic aperture radars. Based on the technology, certain producers, like Metawave, are starting to offer goods geared toward the automotive sector.	Metawave 这样的生产商开始提供专注于汽车行业的产品。
4.2.5 LiDAR	4.2.5 激光雷达
The active ranging technology known as LiDAR (light detection and ranging), uses the laser light pulses round-trip time to compute distances to objects. Low-power, non-visible, and safe for the eyes NIR lasers (900-1,050 nm) are used in robotic and automated applications' sensors. Due to their low divergence, laser beams can estimate distances of up to 200m in direct sunlight by decreasing power degradation with distance. The laser pulse is typically changed direction using a spinning mirror to provide 360-degree horizontal coverage.	被称为激光雷达（激光探测和测距）的主动测距技术，利用激光脉冲往返时间来计算到物体距离。低功率，不可见，对眼睛安全的近红外（NIR）激光器（900-1050 纳米）广泛应用于机器人和自动化应用程序的传感器中。由于其低散度，通过减少随距离增加而导致的功率衰减，激光束可以在阳光直射下估算出高达 200 米的距离。通常使用旋转镜来改变激光脉冲的方向，以提供 360 度的水平覆盖。
Commercial methods create numerous vertical levels using a variety of emitters (between 4 and 128). A 3D point cloud that represents the surroundings is created as a result. Because of their high accuracy in detecting distances, LiDAR sensors are a feasible alternative for creating precise digital maps. Inaccuracy with these sensors typically ranges from a	商业方法使用各种发射器（4-128 个之间）创建了许多垂直层级，最终创建了代表周围环境的三维点云。由于激光雷达传感器探测距离的高精度，其是绘制精确数字地图的可行代替方案。在最糟糕的情况下，这些传感器的不准确通常在 0.1-0.5 米之间。

few millimeters to 0.1-0.5 m in the worst circumstances.	
4.2.5.1 Emerging LiDAR Technologies	4.2.5.1 新兴激光雷达技术
FMCW LiDAR [13] continually produces light to measure an object's speed using the Doppler effect. Few research prototypes appropriate for the automobile market have begun to surface in recent years. Speed observation can aid to increase activity recognition and behavior prediction in addition to target-tracking abilities, for example by detecting the different speeds of a cyclists and a pedestrian's body parts. A solid-state oscillating micro mirror and optical phased array are two of the technologies that fall under the general term "LiDAR," which covers several more optical phased array (OPA). The first method uses tiny mirrors that can revolve around two axes to focus laser beams.	FMCW 激光雷达使用多普勒效应，通过连续发射光来测量物体的速度。近年来，适合汽车市场的少数研究原型开始出现。除了目标跟踪的功能外，观测速度可以帮助提高活动识别和行为预测能力。例如，通过检测骑车者和行人身体部位的不同速度，用来预判他们的行动。固态振荡微镜和光学相控阵是属于统称"激光雷达"下的两种技术，激光雷达还包括其它多种光学相控阵（OPA）。第一种方法是使用能够围绕两轴旋转的小镜子来聚焦激光束。
Devices based on this technology are offered for sale by the manufacturer LeddarTech. Similar to the technique used in phased array radars, optical phased arrays provide rapid and very accurate beam direction control. One of the few companies commercializing products	此类技术的设备由制造商莱德达科技公司（LeddarTech）出售。类似于相控阵雷达中使用的技术，光学相控阵提供了快速且精准的光束方向控制。Quanergy 是为数不多以此概念为基础商业化产品的公司之一。纵观整个视场（FoV），OPA 技术可以使

based on this concept is Quanergy. Over the entire FoV, OPA technology can use random-access scan patterns (field of view). This enables dynamically changing beam density (resolution) and monitoring only particular locations of interest. Combining these qualities enables quick inspection of the entire field of view at low resolution, followed by following objects of interest at greater resolution for improved shape recognition even at great distances [14].	用随机存取扫描模式（视场）。这种技术可以动态改变光束密度（分辨率），并监控感兴趣的特定位置。结合这些特点，可以在低分辨率下快速检查整个视场，然后在更高分辨率下跟踪感兴趣的对象，以便在较远距离上改善形状识别能力。
4.3 Analysis on the Architecture of Autonomous Vehicles	4.3 自动驾驶汽车的架构分析
To improve autonomous vehicles day by day, engineers are exploring and employing more advanced sensors and technology in both software and hardware. The traditional idea for autonomous vehicles has up until now made use of cameras, radar, ultrasonic sensors, and LiDAR. Each subsystem no longer performs its individual tasks independently of the others. The results of one task must be used as relevant information for the next; as a result, autonomous vehicles must be capable of carrying out a wide range of activities in	为了日益改进自动驾驶汽车，工程师们正在探索和采用更先进的软件和硬件传感器和技术。目前为止，传统的自动驾驶汽车传统理念通常使用摄像头、雷达、超声波传感器和激光雷达。每个子系统不再独立地于其他子系统，执行其单独的任务。一项任务的结果必须用作下一项任务的相关信息。因此，自动驾驶汽车必须能在各种场景中执行各种活动。只有软件和硬件相互协作，充分利用彼此优势能力来完成任务，才可以取得最佳结果。

various scenarios. We achieve the best results when hardware and software collaborate and use each other's finest capabilities to complete a task.	
An autonomous system has a number of components and its architectural design that offers an abstract perspective of how the system is structured and operated. A layered design allows for the sharing of information between components via public well-defined communication interfaces. By adjusting a few components to maintain the same communication interface, this characteristic makes it possible to define a similar architecture for all tracks in this challenge. This method shortens the time required for agent development and makes it possible to compare the effectiveness of autonomous navigation using several algorithms for a given job. The most prevalent hardware and software architectural structures will be covered in this section.	一套自主系统具有多个组件和其架构设计，提供了系统如何结构化和操作的抽象视角。分层设计允许组件之间通过公共、定义良好的通信接口共享信息。通过调整少数组件以保持相同的通信接口，这一特性可以为在挑战中的所有轨道定义类似的体系结构。这种方法缩短了代理程序开发所需的时间，并通过给定任务下使用多种算法，来比较自主导航的有效性。本节将介绍最流行的硬件和软件框架结构。
4.3.1 Hardware Architecture	4.3.1 硬件架构
Hardware components are essential for enhancing the safety and redundancy of self-driving systems. These hardware elements are used in combination to	硬件组件对于提高自动驾驶系统的安全性以及冗余性至关重要。这些硬件元件结合使用，用于执行自动驾驶操作。驾驶辅助系统旨在提高驾

conduct automated driving operations. Driving assistance systems are designed to increase the driver's comfort and the safety of the passengers and the surroundings.	驶者的舒适性以及乘客和周围环境的安全性。
·Environmental detector configuration: Self-driving vehicles cannot depend on the singular type of detector; they must include a redundant sensor for safety. The most common sensors for a self-driving automobile include cameras, radars, LiDARs, and GPS. Another common sensor setup for self-driving cars comprises a millimeter-wave radar, a GPS unit, a 16-line laser radar, and other similar sensors.	• 环境检测器配置：自动驾驶汽车不能依赖单一类型的检测器，它们必须包含冗余传感器以确保安全。自动驾驶汽车最常见的传感器包括摄像头、雷达、激光雷达以及 GPS。自动驾驶汽车另一种常见的传感器配置包括毫米波雷达、GPS 装置、16 线激光雷达和其他类似的传感器。
·Vehicle-mounted computing platform: Two of the Industrial Personal Computers (IPCs) compose the computing environment for autonomous cars. To meet automotive gauge specifications, the IPC must be able to operate for an extended period of time in conditions of high temperature and vibration. The hot standby IPC is used instead of the primary control IPC. They both perform online in real time. To ensure safety, the standby IPC output command is switched as soon as the primary control IPC fails.	• 车载计算平台：两台工业用个人计算机（IPCs）构成了自动驾驶汽车的计算环境。为满足汽车仪表规格，IPC 必须能够在高温和振动的环境下长时间运行。使用热备份 IPC 替代主控 IPC。两者都可实时在线进行操作。为确保安全，一旦主控 IPC 发生故障，会立即切换备用 IPC 来输出命令。

·Actuators and Sensors: One of the most crucial parts of self-driving automobiles is the actuator, followed by the sensor. They are essential to preventing the need for human interaction while traveling. To gather information from the environment, a lot of sensors will be required. The numerous actuators will be turned on by sensors, which will then produce the instruction to turn on the last component [15].	• 执行器和传感器：自动驾驶汽车最关键的部件之一是执行器，其次是传感器。两者对于在行驶过程中减少对人类干预的需求至关重要。为了从环境中收集信息，需要安装大量的传感器。传感器会激活众多的执行器，随后传感器将产生指令来激活最后一个部件。
4.3.2 Software Architecture	4.3.2 软件架构
The software architecture of the intelligent vehicle includes public service support and user interfaces for computers. The most crucial aspect of self-driving cars is the communication between components.	智能车辆的软件架构包括公共服务支持以及计算机用户界面。自动驾驶汽车最关键的方面是组件之间的通信。
·Human-machine interaction: This covers remote control intervention, driver interface, and programmer debugging. Emergency response is one of the most important applications for autonomous vehicles. Autonomous automobiles are capable of lane keeping, lane changing, overtaking, and avoiding emergency accidents. The intelligent vehicle’s hardware and software configurations are	• 人机交互：其包括远程控制干预、驾驶员界面以及程序员调试。应急响应是自动驾驶汽车最重要的应用程序之一。自动驾驶汽车具有保持车道、变道、超车以及避免紧急事故的能力。利用智能汽车的硬件和软件配置来评估智能车辆在不同模式下的自动驾驶能力。

used to evaluate the automated driving capacity of the intelligent vehicle in various modes.	
·Public Service Support: This includes services for logging, process observation, and virtual switching. The virtual switch should logically be made up of many virtual buses. Each and every bus has several software modules connected to it. Communication across modules on the same bus is accomplished via the subscription and release mechanism. The virtual switch eliminates the communication function of the module, allowing it to concentrate on its functionality. The statement on the digital bus is logged by the log and sent to the database in accordance with the time sequence.	• 公共服务支持：其包括日志记录、进程观察和虚拟交换的服务。虚拟交换机逻辑上应由多个虚拟总线组成。每个虚拟总线连接着多个软件模块。在同一总线上的模块之间的通信是通过订阅和发布机制实现的。虚拟转换机消除了模块的通信功能，使其可以更专注于自身的功能。数字总线上的信息由日志记录，并按时间顺序发送到数据库。
The messages may also be delivered back to the application layer module that needs debugging, bringing back the test’s observed driving state. This depends on the time. Data about heartbeats are gathered and analyzed through process monitoring. When exceptions are found, the system immediately takes corrective action and notifies the debugging team so they can	这些信息也可能被传回需要调试的应用层模块，从而恢复测试过程中所观察到的驱动状态，但这取决于时间。通过进程监控汇集和分析核心数据，发现异常时，系统会立即采取纠正措施，并通知调试团队，以便他们对系统进行检查。自动驾驶汽车的系统架构涉及五个阶段，下面对此进行讨论。

examine the system. The System Architecture for Autonomous Vehicles involves five stages. They are discussed below.	
·Sensing: The sensing layer consists of a collection of exteroceptive and proprioceptive sensors, which measure information about the outside world and the vehicle itself, respectively. In order for the system to reliably reflect the status of the vehicle and its surroundings, the perception layer must understand and transform the raw data from the sensors that the sensing layer components collect. A layer for sensor management is a valuable tool for architecture design, since it increases flexibility and scalability, allows for the replacement of individual layers or even their entirety, and ensures that the architecture will continue to function as long as its communication interface does. If the set of sensors is altered, there is little to no change in the architecture design.	• 感知：感知层由外部感受器和本体感受器的集合组成，分别测量有关外部世界和车辆本身的信息。为了让该系统可靠地反映车辆及其周围环境的状态，感知层必须理解和转换感知层组件收集到的传感器的原始数据。传感器管理层是框架设计的有价值的工具，因为其增加了灵活性和可扩展性，允许替换单个层甚至整个层，并确保只要通信接口存在，架构将继续正常运行。若传感器集合改变，框架设计几乎没有变化。
1. GPS In a geodesic coordinate frame, which is defined as: i.pgeo k = (lat k,lon k,alt k),	1. 全球定位系统（GPS） 在测地坐标中，其定义为： i.pgeo k = (lat k,lon k,alt k)

where lat and lon stand for latitude and longitude, alt stands for altitude, and k is the time stamp of the frame. This sensor delivers the position of the vehicle at a frequency of 10Hz.	其中，lat 和 lon 代表纬度和经度，alt 代表海拔高度，k 为框架的时间戳。该传感器以 10 赫兹的频率提供车辆的位置。
2. Camera Six cameras are arranged into three stereo pairs, positioned at a height of 1.8m. The stereo right and stereo left cameras' picture sizes are 600×320 (width×height), while the center camera's image size is 1,080×540 (width×height).	2. 照相机 六台照相机被组合成三对立体视觉相机，位于 1.8 米的高度处。右相机和左相机的图片尺寸为 600×320（宽×高），中央相机的图像的尺寸为 1,080×540（宽×高）。
3. LiDAR This sensor produces about 500,000 points per second, or a point cloud, with a 360-degree horizontal field of view at a frequency of 20Hz. It uses 32 laser-simulated channels with 45 degrees of vertical field of view (15 degrees of upper FoV and 30 degrees of lower FoV). Each point is described by position (x, y, z) with relation to the location of the sensor in a Cartesian coordinate system.	3. 激光雷达 该传感器每秒产生大约 500,000 个点，或者说形成一个点云，传感器以 360 度的水平视场、20 赫兹的频率进行工作。该传感器使用 32 个激光模拟通道，每个通道的垂直视场为 45 度（上方视场为 15 度，下方视场为 30 度）。每个点都通过其在笛卡尔坐标系中相对于传感器位置（x, y, z）来描述。
4. CAN Bus This proprioceptive pseudo sensor offers data on the interior status of the car, including speed, steering angle, and shape dimensions.	4. 控制器局域网总线 该本体感受伪传感器提供了有关汽车内部状况的数据，包括速度，转向角度以及形状尺寸。

5. Object Finder This fictitious sensor provides data on the location and orientation of all moving and stationary objects such as pedestrians and vehicles as well as information on the shape and status of traffic lights that are a part of the simulated environment.	5. 物体检测器 该虚构传感器提供有关所有移动和静止物体的位置和方向的数据，如行人和车辆，以及仿真环境中交通信号灯的形状和状态的信息。
·Perception: During this step, the automated vehicles sense their environment by a lot of sensors and determine its location in correspondence to those surroundings. It also includes LiDAR, radar, real-time kinetics, cameras, and others, processing the data as soon as data are supplied to the recognition modules from sensors. A control system, Vehicle Positioning and Localization (VPL), Unknown Obstacles Recognition (UOR) modules, etc., are the typical components of an autonomous vehicle.	•感知：该过程中，自动驾驶汽车通过众多传感器感知周围环境，并确定其在周围环境中的位置。这个过程还包括激光雷达，雷达，实时动力学，摄像头等传感器。一旦传感器将数据供给识别模块，就会立即对数据进行处理。自动驾驶汽车的典型组件包括控制系统，车辆定位（VPL），未知障碍识别模块（UOR）等。
The components of the perception layer use methods and theoretical definitions from several academic domains, including computer vision, linear algebra, probability, and machine learning to transform sensor input into meaningful information. These data permit the representation of the vehicle state and	感知层组件利用了来自不同学术领域的方法和理论定义，包括计算机视觉、线性代数、概率和机器学习，将传感器输入转换为有意义信息。这些数据感知层的数据可以被用来表示车辆状态和周围环境，以供导航层的组件在架构设计中使用。

surrounding environment in order to feed the navigation layer components in the architectural design.	
The most important tasks for automated vehicles are detection of road borders, detection of obstacles, identification of pedestrians and vehicles, detection of traffic signs, detection of lanes, detection of traffic lights, and estimation of vehicle body state.	自动驾驶汽车最重要的任务包括检测道路边界、探测障碍、识别行人和车辆、检测交通标志、探测道路、检测信号灯以及估计车身状况。
For identifying obstacles, the support vector machine method is frequently employed. The main applications of convolutional neural network techniques in the detection of pedestrians and vehicles and classification and identification of that rapid convolution that occurs quickly Traffic signs are recognised using neural network technology.	为了识别障碍，常采用支持向量机的方法。卷积神经网络技术在行人及车辆探测，以及交通标志快速出现的快速卷积的识别和分类中具有主要应用。
·Obstacle Detection: CaRINA Agency uses two vision systems: a stereo camera-based system and a LiDAR system with perception capabilities for Track 1, Track 2, and Track 3. They execute the obstacle identification task and provide three-dimensional point clouds in a Cartesian coordinate system (x, y, z).	•障碍物探测：卡里纳机构采用两种视觉系统：基于立体相机的系统和带有感知的激光雷达系统，分别用于轨道 1，2，3。它们执行障碍识别任务，并提供以笛卡尔坐标系表示的三维点云数据。

·LiDAR-Based Obstacle Detection: Contrary to commercial LiDAR, the simulated sensor provides neither intensity nor ring data because it is a ray-casting approach. Therefore, strategies relying on ring compression and virtual scanning are not usable during competition.	• 基于激光雷达的障碍物检测：与商业激光雷达相反，该模拟传感器采用光线投射的方式，既不提供强度数据也不提供环数据。因此，在比赛中无法使用基于环压缩和虚拟扫描的策略。
·Stereo-Based Obstacle Detection: Driving in urban environments necessitates precise and accurate 3D perception of the surroundings. LiDAR was a useful sensor for this work on Tracks 1 and 3. Track 2 is instructed to travel to a specific location using only cameras. Beyond LiDAR, there are no sensors in the challenge that can produce RGB-D images or depth data. We performed scene reconstruction and obstacle recognition using a stereo system. The stereo method was chosen because it allows for 3D reconstruction using just two monocular cameras equipped with the right calibration matrix.	• 基于立体声的障碍物检测：在城市环境中行驶需要对周围环境进行精准的三维感知。轨道 1、3 常用激光雷达传感器工作。而轨道 2 只可以使用摄像头导航到特定位置。除激光雷达外，没有其它传感器能在该挑战中生成 RGB-D 图像或深层数据。使用立体声系统进行场景重建和障碍物识别。采用该方法是因为它只需要两个正确校准矩阵的单目相机，来进行三维重建。
·Hazardous Obstacle Monitor: Risk assessment is yet another crucial element of an autonomous system for ensuring safe driving, in addition to obstacle detection. It analyzes potential risks to accidents, such	• 危险障碍物检测：除障碍物探测外，风险评估是自动驾驶系统确保安全驾驶的另一关键要素。它分析可能导致事故的潜在风险，例如与其它车辆的碰撞。与静止障碍物、移动障

as collisions with other traffic participants. Collisions with stationary impediments, moving obstacles, and unforeseen obstacles are the three basic categories into which collisions fall (which may occur due to occlusions). Therefore, both binary collision prediction and quantitative risk appraisal can direct decision-making systems toward the proper course of action for collision avoidance.	碍物以及意外障碍物的碰撞，是碰撞的三种基本类别（可能由于遮挡而发生）。因此，二元碰撞预测以及定量风险评估可以引导决策系统采取适当的行动来避免碰撞。
Decision and Planning: This stage makes decisions, plans, and directs the movement of the autonomous vehicles using the information received during the perception process. This stage, which the brain would represent, is where choices are made on things like obstacle avoidance, action prediction, etc. The decision is based on current and historical information, including real-time map data, traffic contains details and patterns, user data, and so on.	决策和规划：在这个阶段，自动驾驶汽车利用感知过程中获取的信息，进行决策、计划以及指导运动。该阶段类似于大脑的功能，涉及到诸如障碍物躲避、行为预测等方面的选择。决策基于当前和历史信息，包括实时地图数据、交通状况的细节和模式、用户数据等。
There could be a data logging module which keeps track of mistakes and data for later use. The primary responsibility of the driving mission choice is to determine the intelligent vehicles driving style, switching lanes, catching up, making a left	该阶段可以包括一个数据记录模块，用于跟踪错误和数据，以备日后使用。驾驶任务选择的首要责任是确定自动驾驶汽车的驾驶风格，包括变道、加速、十字路口左转、交叉路

turn at a crossroads and a right turn at a junction, from starting and stopping at junctions.	口右转以及在交叉路口的起步和停车。
Local route plannings primary goal is to create a suitable path for each selected driving style, which is typically between 10 and 50 meters long. In order to produce the steering wheel angle and move laterally along the specified track, lateral motion control is primarily responsible for these tasks.	本地路线规划的主要目标是为每种选择的驾驶风格创建合适的路径，长度通常在 10-50 米之间。为了产生转向角度，并沿着特定轨迹横向移动，横向运动控制主要负责这些任务。
·Control: This module controls the autonomous vehicles physically by performing tasks such as steering, stopping, and accelerating after receiving information from the planning and decision module.	• 控制：该模块在接收到规划和决策模块的信息后，对自动驾驶汽车进行物理控制，执行转向、停车和加速等任务。
·Lateral Control: The model-based predictive control (MPC), which manages the lateral control that provides the engineering signal, optimizes a cost function over a preset time horizon H, producing a series of actions, one for each time step △t. The immediate action is carried out, and the process is continued in the following time step, resulting in a narrowing of the horizon.	• 基于模型的预测控制（MPC）管理提供工程信号的横向控制。MPC 在预设的时间范围 H 内优化成本函数，从而产生一系列动作，每个时间步长△t 对应一个动作。立即采取行动，并在随后的时间步长中继续该过程，导致视界变小。

·Longitudinal Control: The agent must have a speed rate change as the Markov decision processes (MDP) problem's solution. A new agent's velocity can be computed using the current agent's velocity. PI controls, or proportional-integral, perform this tracking.	• 纵向控制：作为马尔可夫决策过程（MDP）问题的解决方案，主体必须具备速度的变化。可以使用当前主体的速度计算新的主体速度。PI 控制或比例积分，可以执行该追踪。
·Chassis: Last step is about making an interaction with the mechanical parts that are connected to the chassis, including the gear system, brake motor, steering wheel motor, and accelerator and brake pedal motors. The control module signals manage these.	• 底盘：最后一步是与连接到底盘的机械部件进行交互，包括齿轮系统、制动电机、方向盘电机、加速器和制动踏板电机。该控制模块信号管理这些部件。
·Sensors: We discuss the design, functionality, and utilization of some key sensors after discussing the overall communication and detector architecture of an automated vehicle.	• 传感器：在讨论了自动驾驶汽车的整体通信和检测器框架后，我们将讨论一些关于关键传感器的设计、功能和使用方式。
Ultrasonic sensor: These sensors operate at frequencies ranging from 20 to 40kHz. A magneto-resistive tissue used to determine the distance between two objects produces these waves. By comparing the emitted wave's time-of-flight (ToF) to the echoing signal, the distance is determined. The range of	超声波传感器：这些传感器的工作频率在 20-40 千赫之间。利用磁阻元件产生波，来确定两个物体之间的距离。通过比较发射波的飞行时间与回波信号，来确定距离。超声波传感器的范围通常小于 3 米，距离相当短。

ultrasonic sensors is often less than 3m, which is quite short.	
Every 20ms, the sensor output is refreshed, which prevents it from adhering to the ITS's rigorous QoS requirements. These sensors have a very limited beam detecting range and are directional. Therefore, to obtain a full-field vision, numerous sensors are required. Multiple sensors, however, will impact one another and can result in significant ranging errors. The conventional approach will provide a unique signature or identifying code that will be required to eliminate the echoes of other detectors working in close proximity.	传感器输出每20毫秒刷新一次，这样无法满足智能交通系统（ITS）的严格服务质量要求。这些传感器的光束探测范围十分有限，并且是定向的。因此，为了获得全景视野，需要使用大量的传感器。然而，多个传感器之间相互影响，可能导致显著的测距误差。传统方法将提供唯一的签名或识别代码，以消除邻近工作的其它探测器的回波。
·Radio Detection and Ranging: RADARs are used in AVs to scan the environment for cars and other objects. RADARs are frequently used for both military and civilian purposes, such as airports or meteorological systems, and they function in the millimeter-wave (mm-Wave) frequency range. Various frequency bands, consisting of 24, 60, 77, and 79GHz, are used in contemporary automobiles and have a measurement range of 5 to 200m.	• 无线电探测和测距：自动驾驶汽车使用雷达来扫描周围环境，探测其它汽车和物体。雷达被广泛运用于军事和民用领域，例如机场和气象系统，其工作频率在毫米波频段。现代汽车中使用了各种频段，包括24、60、77 和 79 千兆赫，测量范围为 5-200 米。

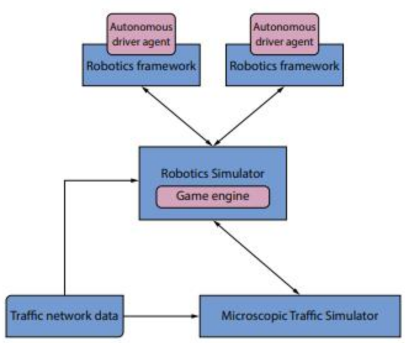
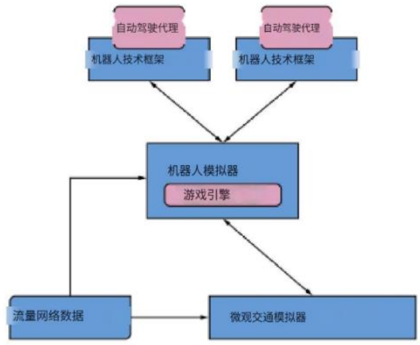
By figuring out how long it took from the transmitter and the obtained echo, the distance between the AV and the object is determined. To increase range resolution and the ability to detect numerous targets. RADARs in AVs employ collections of micro-antennas that produce a series of lobes. Because mm-Wave RADAR can directly measure short-range aims in any direction by utilizing Doppler shift variation, it has greater penetrability and greater bandwidth. Since mm-Wave radars have a longer wavelength, they feature anti-pollution and anti-blocking capabilities that enable them to operate in fog, rain, snow and low light.	通过计算发射器和接收到的回波之间的时间差，可以确定自动驾驶汽车与物体之间的距离。为了提高测距分辨率以及探测多个目标的能力。自动驾驶汽车中的雷达采用了可产生一系列波瓣的微天线集合。由于毫米波雷达可以通过多普勒频移变化量直接测量任意方向上的短距离目标，因此具有强大的穿透能力和更大的宽带。如果毫米波雷达波长较长，那么它就具有抗污染和抗遮挡能力，从而能够在雾、雨、雪和低光照环境下运行。
·LiDAR: Light Detection and Ranging: The spectra at 905 and 1,550 nm are used in LiDAR. Modern LiDAR operates in the 1550 nm wavelength range to minimize retinal degeneration due to the 905 nm spectrum that may harm the human retina. LiDAR can operate at a distance of up to 200m. LiDAR is divided into 3 categories: 2D, 3D, and solid-state models. A single laser beam is dispersed over a fast-rotating mirror in a 2D LiDAR. Several lasers can be placed on the pod so	• 激光雷达：激光探测与测距：激光雷达使用的光谱为 905 纳米和 1550 纳米。现代激光雷达在 1550 纳米的波长范围内工作，以最大程度减少由 905 纳米的光谱可能会损坏人类的视网膜, 而导致的视网膜变性。激光雷达可以在高达 200 米的距离内测量。激光雷达分为三类：2D、3D 和固态模型。在二维激光雷达中，单个激光束通过快速旋转的镜子进行扩散。可以在吊舱上放置多个激光器，

that a 3D LiDAR can produce a 3D image of its surroundings.	以便三维激光雷达生成周围环境的3D 图像。
·Camera: Depending on the wavelength of a device, shutter in autonomous vehicles can be categorized as infrared light or visible light. The camera's image sensors are constructed using two technologies: charge-coupled devices and complementary metal oxide semiconductors. Depending on lens quality, a camera can capture images out to a maximum range of about 250m. The visible cameras have red, green and blue bands (RGB)and work within the same range of wavelength as the human eye, or of 400-780nm.	•摄像头：根据设备的波长，自动驾驶汽车的快门可分为红外光和可见光。摄像头图像传感器采用了两种技术：电荷耦合器件（CCD）和互补金属氧化物半导体（CMOS）。根据镜头质量，摄像头可在最大范围约为250 米之内捕捉图像。可见光摄像头具有红、绿、蓝三个波段（RGB），工作波长与人眼相同，即 400-780 纳米。
There are two VIS cameras coupled with fixed focal lengths that produce a new channel with depth D data, mandatory for producing stereoscopic vision. Using this function, cameras (RGB) can get a 3-dimensional view of the environment of the vehicle. Passive sensors ranging from 780nm to 1 mm in wavelength are being used by the infrared (IR) camera. The vision control is provided by IR sensors in autonomous vehicles in peak illumination.	两个可见光（VIS）摄像头与固定焦距结合，可产生一种具有深度 D 数据的新通道，这是产生立体视觉所必需的。使用此功能，摄像头（RGB）可以获得汽车环境的三维视图。红外（IR）相机使用波长范围为 780 纳米至 1 毫米的被动传感器。在自动驾驶汽车中，红外传感器在峰值照明下提供视觉控制。

This camera assists autonomous vehicles in their works like detecting objects, side view control, recording of accidents, and blind spot detection (BSD). Nevertheless, adverse weather circumstances like snow and fog and variations in the quality of the light affect how well the camera performs [16].	这种摄像头可协助自动驾驶汽车进行物体检测、侧视控制、事故记录和盲点检测（BSD）等工作。然而，恶劣的天气条件，如雪、雾和光线质量的变化，都会影响摄像头的性能表现。
·Global Navigation Satellite System (GNSS): The most popular technology for obtaining precise position data on the Earth's surface is GNSS. The GPS is a US-owning utility that offers customers with aligning, precise site, and time frame services and is the most well-known GNSS system. GPS is a vital component of the global information architecture, which pervades all aspects of today's society because of its free, open, and reliable nature.	• 全球导航定位系统（GNSS）：获取地球表面精确位置数据的最流行技术是 GNSS。全球定位系统（GPS）是美国拥有的公用事业公司，为用户提供对齐、精确定位和时间同步服务，是最知名的 GNSS 系统。GPS 是全球信息框架的重要组成部分，由于其免费、开放和可靠的性质，遍及当今社会的各个方面。
The US DoD (Department of Defense) created the GPS in the 1970s and has three sections space, control, and user section. The US Air Force created, maintained, and ran control components and GPS system's space. Operational satellite count for the space segment is 31, at least 24 of which are typically available.	美国国防部（DoD）在 20 世纪 70 年代创建了 GPS，并将其划分为空间、控制和用户三个部分。美国空军创建、维护和运行 GPS 系统的控制组件和空间部分。空间部分的运行卫星数量为 31 颗，通常至少 24 颗可用。这些卫星位于高度为 20,200 公里的中地球轨道上（MEO），每颗卫星

While in medium Earth orbit (MEO) at the height of 20,200km, each of these satellites completes two daily orbits of the planet. Any receiver placed on the surface of the planet can receive signals from 6 to 12 satellites in the S-band and L-band fluctuations range because of its configuration.	每天绕地球完成两次轨道。任何放置在地球表面的接收器都可以根据其配置，接收来自 S 频段和 L 频段波动范围内的 6-12 颗卫星的信号。
The method for separating into separate groups based on shared features is referred to as user segmentation [17]. It is important to note that GNSS signals have a number of flaws that reduce the system’s accuracy, including the following: (1) timing inaccuracies resulting from discrepancies between the receiver’s quartz clock and the satellite’s atomic clock, (2) signal lags brought on by signal propagation through the troposphere and ionosphere, (3) multipath impact, and (4) uncertainties in the orbit of a satellite. Inertial Measuring Units (IMU), radars, cameras, and LiDARs, among other sensors, are coupled with satellite data to create a more comprehensive picture to produce trustworthy location data in order to enhance the precision of today’s car positioning systems.	基于共享特征将用户分为不同组的方法称为用户分割。需要注意的是，GNSS 信号存在降低系统的精度的缺陷，包括以下几点：（1）由于接收器的石英钟和卫星的原子钟之间的差异而导致的定时不准。（2）信号在对流层和电离层中传播带来的信号滞后。（3）多径撞击。（4）卫星轨道上的不确定性。惯性测量单元（IMU）、雷达、摄像头和激光雷达等传感器，与卫星数据相结合，以创建更全面的图像，生成可靠的位置数据，从而提高当今汽车定位系统的精度。

4.4 Analysis on One of the Proposed Architectures	4.4 对拟议提议架构之一进行分析
A software architecture is suggested for the simulation of in a traffic scenario, an autonomous vehicle. As a result of the requirement that each simulator utilize all available resources in Figure 4.1 [18]. Figure 4.1 design has a distributed nature. There are four main modules: Microscopic Traffic Simulator, Robotics Simulator, Coherent Network Data and Autonomous Vehicle interface and control.	现提出了一种用于模拟交通场景中自动驾驶车辆的软件架构。由于要求每个模拟器利用图 4.1 中的所有可用资源，而产生了这种软件架构。该图设计具有分布式的特征。包括四个主要模块：微观交通模拟器、机器人仿真器、协同网络数据、自动驾驶车辆接口和控制。
·Microscopic Traffic Simulator It simulates nearly every type of vehicle in a manner that is similar to the macroscopic modeling of actual traffic flows. Additionally, it keeps up with all construction systems, such as induction loops and traffic signal schedules. Because of the simulator's adaptability, a pretty high level of statistical template could be linked to examine the patterns of traffic behavior of autonomous vehicle strategies for individuals and groups.	• 微观交通模拟器： 该模拟器以类似于实际交通流宏观建模的方式，模拟了几乎所有类型的车辆。此外，能够追踪所有构造系统，如感应线圈、交通信号灯计划等。由于模拟器的适应性，可以与高水平的统计模板连接，以研究个人或群体的汽车驾驶车辆策略的交通行为模式。

 **Figure 4.1** An autonomous vehicle simulator in a traffic environment is proposed.	 图4.1提出了一种交通环境下的自动驾驶汽车模拟器。
·Robotics Simulator	• 机器人仿真器
It simulates every autonomous vehicle in the surroundings, including every one of its sensors, actuators, and reflectors of everything in the immediate vicinity. Additionally, it has a game engine with strong physics and visuals modules for immersive 3D animation.	该仿生器模拟周围的每辆自动驾驶汽车，包括每辆汽车的传感器、执行器和周围所有物体的反射器。此外，具备配有出色物理和视觉模块的游戏引擎，用于沉浸式 3D 动画效果。
·Coherent Network Data	• 协同网络数据
It represents the topology of the traffic network and the data for its accurate 3D surroundings.	该模块表示交通网络的拓扑结构以及准确的 3D 环境数据。
·Autonomous Vehicle Interface and Control	• 自动驾驶车辆接口与控制
When using an agent-based methodology, an external soft- ware programme motive force is frequently used to carry out high-level tasks for self-sufficient cars. For smooth real/ digital worldwide development and sensor/actuator permutation, a hardware abstraction layer (HAL)is used.	在使用基于主体的方法时，通常使用外部软件程序作为自主车辆执行高级任务的动力源。为了实现顺畅的真实/数字世界发展和传感器/执行器的组合，常用硬件抽象层（HAL）。

·Virtual Server for Data Transmission	• 数据传输虚拟服务器
Data transfer is essential. As a result, the data transmission module needs to be reliable, secure, effective, and bug-free. Each module involved is seen as a node connected, with no impact with other nodes, when the related node is idle. The other modules will not submit any data to module A if A just requires data from module B.	数据传输至关重要，因此，数据传输模块必须可靠、安全、有效且无缺陷。每个参与的模块都被视为一个相互连接的节点，在相关节点空闲时不会对其他节点产生影响。若模块 A 只需要来自模块 B 的数据，则其他模块不会向模块 A 提交任何数据。
Efficiency should be given the most consideration because a transmission delay is detrimental for automated driving. Though the ROS (Robot Operating System) is a famous system utilized for robotics, testing has revealed that due to its cross-platform capability and real-time performance, this system is not particularly ideal for self-driving vehicles when the related node is idle. Additionally, decoupled nodes in their IPC (“Cocktail”) increase system availability in the event of partial failure.	由于传输延迟对于自动驾驶来说是有害的，因此最应该考虑效率。尽管机器人操作系统（ROS）是用于机器人领域的著名系统。但测试表明，由于其跨平台能力和实时性能，该系统在相关节点空闲时，该系统对于自动驾驶汽车并不特别理想。此外，在 IPC（进程间通信）中的解耦节点可以增加在部分故障时系统的可用性。
However, a destination-based model is employed rather than a channel-based approach. The virtual server that connects to all the nodes and relays all the messages carries out the connection checking. So, a	然而，采用基于目标的模型，而不是基于通道的方法。连接到所有节点并中继所有信息的虚拟服务器将执行连接检查。因此，为了解决这些问题，创建了一个名为“进程间通信

data transmission module for self-driving vehicles called “Project Cocktail” was created as a result to address these issues.	项目”的自动驾驶车辆数据传输模块。
A crucial mechanism for data transmission and sharing, Project Cocktail may receive and send messages to and from network peers (using user datagram protocol). Project Cocktail, albeit created for this particular application, is a general-purpose intermediate that treats all flow of data as simple binary creeks and is not dependent on any specific data format used by network peers.	作为数据传输和共享的关键机制，“进程间通信项目”可以与网络对等体进行消息的接收和发送（使用用户数据报协议）。尽管该项目是为这个特定应用程序而创建的，但它是一个通用的中程序，它将所有数据流视为简单的二进制数据传输流，不依赖网络对等体使用的任何特定数据格式。
Because of the way it is built, it is very resilient in the sense that it functions well when a large diversity of data types is created by a large number of network neighbors. Testing on this single server design demonstrates that it is less scalable than the distributed SimpleComms design. Compared to the “singleton of data transferred, the ‘all to all’ mode single,” controlling for the net amount has a higher latency, indicating that “it is best to avoid listening to the same module twice.” SimpleComms incorporates crowding avoidance for each individual module by	如果它的架构方式如此，该系统就具有显著的弹性。在大量网络邻居生成多种数据类型的情况下，它仍能良好运行。对该单服务器设计进行测试表明，其可扩展性不如分布式的简单通信设计。与“数据传输单例，‘全对全’模式单一”相比，控制净额会导致更高的时延，表明“最好避免两次监听同一模块”。简单通信通过在本地服务器之间分布消息中继工作负载，为每个单独的模块引入拥挤避免机制。

distributing the message-relaying workload across the local servers.	
4.5 Functional Architecture of Autonomous Vehicles	4.5 自动驾驶汽车的功能架构
In this section, the functional infrastructure for self-driving vehicles that has resulted in our research is summarized here. It combines all of the functional elements already mentioned and distributes them among the vehicle platform and cognitive driving intelligence components. Additionally, this adheres to our suggestion of achieving a reasonably clear separation between the two. Some elements for technical and practical considerations both the vehicular platform and the driving intellectual ability, are assigned power management and diagnostic testing	本节总结了研究中得出的自动驾驶汽车的功能框架。该框架将之前提到的所有功能元素结合起来，并将它们分配给车辆平台和认知驾驶智能组件。此外，这也符合我们提出的在两者之间实现合理清晰的分离的建议。出于技术和实际考虑，一些元素为车辆平台以及驾驶智能能力分配了能量管理和诊断测试功能。
However, the duties and area of operation are slightly varied for each allotment. Although conceptually united, the capable sensing and global model aspects are divided within those that deal with the vehicle’s exterior surroundings and those that deal with the ego vehicle platform. When the functional infrastructure is refined to become a	然而，每个分配的指责和操作领域略有不同。若要使自动驾驶系统在处理车辆外部环境和本车平台时都能充分发挥感知能力和全局模型的作用，即便它们在概念上是统一的，也需将这两方面分开处理。在必要时，这种分离使得通过 ISO 26262 方法将功能基础设施细化为技术基础设施时，更容易建立不同的技术实施

technical infrastructure via ISO 26262 method, the separation makes it easier to establish different technical implementations, if necessary. As demonstrated, depending on how much operation and fusion is necessary, the sensing components' outputs are sent either directly or indirectly to remaining perception, decision, and control components.	方案。正如所示，根据所需的操作和融合程度，感知组件的输出要么直接要么间接地发送到剩余感知、决策和控制组件。
Creating a data connection between localization and sensor fusion is beneficial. At set points along predetermined routes, some sensors may show repetitive trends such as an increase in false positives or dropouts. An intriguing area of research involves altering a sensor's degree of confidence based on geographic location, and the design should not be a stumbling block. The relationship between the sensor components and the semantic understanding component is another intriguing data link.	在定位和传感器融合之间建立数据连接是有益的。在预定路线的特定点上，一些传感器可能会显示出重复的趋势，如假阳性或丢失的增加。一个有趣的研究领域涉及根据地理位置改变传感器的置信度，而其设计不应成为阻碍。传感器组件和语义理解组件之间的关系是另一个有趣的数据连接。
There are three situations where this is helpful. First, so-called focused attention techniques are advantageous in some specific autonomous driving circumstances. Focused attention entails	在三种情况下这种方法是有效的。第一，在一些特定的自动驾驶环境中，所谓的集中注意技术是有优势的。集中注意需要更深入地研究周围环境的某个区域。这可能需要传感器

delving deeper into a certain area of the surroundings. This might call for the sensors to physically move or for configuration adjustments (such as altering the zoom on a lens or moving or adjusting a cameras field of view). Most autonomous cars' sensors are now physically bound to a fixed attitude with regard to the vehicle coordinate system. However, it is relatively typical in the area of mobile and intellectual robotics. To have, for example, a pan-tilt-zoom image sensor to help the robot in a search experiment.	进行物理移动或进行配置调整（例如改变镜头的焦距，移动或调整摄像头的视野）。大多数自动驾驶汽车的传感器都与车辆坐标系的固定姿态物理绑定。然而，在移动和智能机器人领域，相对典型。例如，可以使用云台变焦图像传感器来帮助机器人进行搜索实验。
Second, sensor adjustment during runtime adjustments may be required (for example, changing levels of exposure based on the time of day, provoking recalibration if physical adjustment changes are suspected). Third, the semantic understanding component can use communication transceivers as a type of sensor or actuator to react to arriving communication requests, post ego vehicle data, and request asynchronous details. Such communication requirements are frequently a critical component of cooperative driving scenarios, in which a vehicle is constantly in communication	第二，可能在运行时调整传感器设置（例如，根据时间更改曝光水平，如果怀疑物理调整发生变化，则需要重新校准）。第三，语义理解组件可以使用通信收发器作为一种传感器或执行器，以相应到达的通信请求、发布自身车辆数据并请求异步详细信息。在协同驾驶场景中，车辆需与周围建筑及邻近车辆保持持续通信，此类通信需求常是其关键组成部分。

with the surrounding buildings and other neighboring automobiles.	
Energy management from the viewpoints of mission accomplishment and total vehicle energy demands is one of the decision and control components (internal and external lights, HVAC). In comparison, the vehicle platforms component of energy management controls regenerative braking, the integration of hybrid propulsion systems, and in a portion of electric and hybrid vehicles, charging management and cell load balancing. Since our perception technical implementation decision and control system have been slow to respond to unexpected events as aspect of the deliberate control, the reactive command in this design is dedicated to the vehicle platform.	从任务完成和整车能量需求的角度来看，能量管理是决策和控制组件（内外照明、暖通空调）之一。相比之下，能源管理的车辆平台控制再生制动、混合动力系统的集成，以及在部分电动和混合动力汽车中的电池充电管理和电池单元负载平衡。我们的感知技术实施决策与控制系统属于审慎控制的一部分时，它对意外事件反应迟缓。本设计中的车辆平台专门采用了反应式指令。
Additionally, having reactive command inside the car, it is easier to ensure a minimal amount of self-protection for the car’s platform if the perceptual driving system fails or becomes completely incapacitated. The vehicle platform also includes the control components for passive safety features like	此外，若感知驾驶系统发生故障或完全无法运行，车辆内部具有反应性命令，更易确保车辆平台的最低自我保护能力。车辆平台也包括被动安全特性的控制组件，如安全气囊、安全带预紧器以及与这些安全特性紧密相连的其他功能，并且不易在其它车辆平台重新利用。由于本文的篇幅

airbags, seat belt pretensioners, and other features that are tightly tied to and it is unlikely that it will be easily repurposed in other vehicle platforms. Due to the limited space in this work, the connections between the functional parts have not been depicted on the automobile platform.	有限，未描述汽车平台上功能部件之间的连接关系。
Platform stability, responsive control, and motion control actuator abstraction are all features seen in more recent vehicles. As a result, the vehicle platform's uniqueness is less than the driving intelligence. However, it is crucial to emphasize that the "Propulsion/Steering/Braking" component abstracts the actual actuation systems [19].	平台稳定性、响应控制以及运动控制执行器抽象化都是现代车辆的功能。因此，与驾驶智能相比，车辆平台的独特性较小。但是，必须强调的是，"推进/转向/制动"组件抽象化了实际的执行系统。
4.6 Challenges in Building the Architecture of Autonomous Vehicles	4.6 构建自动驾驶汽车架构的挑战
Automated vehicles are now a reality after more than 50 years of continuous development and research. Several challenges remain in the development of a completely autonomous method for driverless vehicles. We go over the problems that are frequently raised in research on AI in AV in this part. The many benefits that AV offers are highlighted by research on the subject. No real-world	经过50多年的持续发展和研究，自动驾驶汽车现已成为现实。无人驾驶汽车完全自主的方法开发中仍存在一些挑战。在这部分，我们将讨论在自动驾驶汽车人工智能研究中经常提出的问题。研究突出了自动驾驶汽车所提供的许多好处。在行人检测方面，尚未进行实际测试来查看建议方法在实时情况下识别事物的效果。重障碍物有时会导致行人方向与另

testing is done in pedestrian detection to see how well the suggested approaches identify things in real-time. Heavy impediments can sometimes cause a pedestrian's orientation to differ from another's image mask, which can lead to inaccurate orientation assessment. Therefore, no algorithm is entirely precise or quick. When spotting pedestrians in the dark, accuracy and quickness must be traded off.	一个图像蒙版不同，从而导致方向评估不准确。因此，没有算法是完全精准或快速的。在黑暗中发现行人时，必须权衡准确性和速度。
Behavioral forecasting of pedestrians is frequently disregarded. The majority of research articles on trajectory identification in trajectory planning relied solely on simulation or presented challenges to solutions utilizing deep learning algorithms, with little to no real-world demonstration of their technique. The papers that did use real-world methods are now out of date. The Model Predictive Control method is the primary algorithm used for lateral motion control in motion control.	行人行为的预测经常被忽视。大多数关于轨道规划中轨迹识别的研究文章仅依赖模拟，或是针对利用深度学习算法的解决方案提出挑战，但几乎没有在实际演示他们的技术。使用真实世界方法的论文现已过时。在运动控制中，模型预测控制方法是用于横向运动控制的主要算法。
It nevertheless has a limited ability to detect faults, and uncertainties that do not fit the specified conditions are not completely eliminated. The literature	尽管其可以检测一些故障，但是无法完全消除那些不符合特定条件的不确定性。文献检索受限于关于自动驾驶汽车透明度的研究较少，而且

search was constrained because there are few studies on transparency in self-driving cars and no real-world implementation for nonfunctional criteria. The cognitive bias increases, as it is more likely that people will be impacted by fatal crashes that include various types of driverless cars rather than the new novel experiences that automated vehicles can provide due to the rapidly changing nature of technology.	没有针对非功能性标准的实际实施。随着认知偏见增加，人们更有可能受到包括各种类型无人驾驶汽车在内的致命事故影响，而不是自动驾驶汽车提供的新奇体验。
4.6.1 Road Condition	4.6.1 路况
The condition of roads could be little surprising and may shift over time. In several places, there exist massive, seamless, well-marked roads. In further cases, there are no markings on roads and the road is gravely decayed. Roads are poorly drafted, there are pits, highlands, and underpass paths, and equivalent conditions prevail on par to external direction signs.	道路状况可能会出人意料，并且随着时间推移而变化。在许多地方，存在宽阔、平坦、标记清晰的道路。而在其他情况下，道路上没有标线，路面严重破损。道路设计不良，有坑洼、高地和地下通道，类似的情况也存在于外部指示牌上。
4.6.2 Weather Condition	4.6.2 天气状况
The weather is another troublemaker. Weather can be cloudless, or it can be wet, windy, and rainy. Autonomous cars should be capable of driving in all meteorological states. No room for mistakes or shutdowns.	天气是另一个麻烦的因素。天气可以是晴朗的，也可以是潮湿、多风和多雨的。自动驾驶汽车应该能够在所有气象条件下行驶。这就意味着在任何情况下，都不能出错或停止运行。

4.6.3 Traffic Condition	4.6.3 交通状况
Self-automated vehicles should adapt to different traffic scenarios on public roads. They would have to navigate a large number of pedestrians while sharing the roadway with some other driverless vehicles. Most emotions are present everywhere humans are involved. It is possible to have traffic that is heavily controlled and autoregulated.	自动驾驶汽车应适应在公共道路上的不同交通场景。它们必须在与其他无人驾驶汽车共享道路的情况下，驾驶通过大量行人。大多数情感存在于人类参与的任何地方。交通情况可能会受到严格控制和自动调节。
However, there are many times when anyone might be overriding the law quite often. Unexpected things may result in the exploration of an object. When there is heavy traffic, movement of even a few centimeters each minute counts. A traffic jam may form if a larger number of such vehicles are on the roadway hoping for traffic jams to move.	然而，很多时候任何人都可能经常违法。意外事件可能导致对对象的探索。在交通拥堵时，即使每分钟只移动几厘米也很重要。大量这样的车辆如果在道路上盼着拥堵的交通能够疏通，那么可能就会造成交通堵塞。
4.6.4 Accident Responsibility	4.6.4 事故责任
The crucial feature of autonomous vehicles is their accident liability. Who is to be blamed for crashes involving autonomous vehicles? While talking about self-driving automobiles, the operating system will be the key element that controls the car and assists in making all significant decisions. In contrast to the	自动驾驶汽车的关键特征是其事故责任。谁会为涉及自动驾驶汽车的碰撞负责？谈及自动驾驶汽车，操作系统是控制车辆并辅助做出所有重要决策的关键要素。与最初的原型相比，那些原型展示了实际坐在方向盘后面的人，而谷歌最新的概念省略了方向盘和仪表盘。

original prototypes, which depicted a person actually seated behind the wheel, Googles most recent concepts omit a steering wheel and dashboard.	
How does a person inside the vehicle intend to manage the car in the sudden situation when the car does not appear to have any controls, such as a brake pedal, steering wheel, or an accelerator pedal? The passengers and drivers of AVs will often be relaxed and may not pay close attention to traffic problems due to the nature of these vehicles. If they need to focus on something, by the time they have to answer, it might be too late to stop it.	当汽车似乎没有任何控制装置（如刹车踏板、方向盘或加速踏板）时，车内的人员打算如何在突发情况下控制车辆？由于自动驾驶汽车的特性，车内的驾驶员和乘客往往会感到很放松，可能不会密切关注交通问题。如果他们需要专注于某事，当他们必须做出响应时，可能为时已晚。
4.6.5 Radar Interference	4.6.5 雷达干扰
Radar and laser beams are used by automated cars to navigate. While the lasers are mounted on the roof, the sensors are mounted on the body of the vehicle. Radar works by identifying radio wave reflections from nearby moving objects. While driving, a car continuously emits radio frequency waves that are reflected off of other adjacent objects and by other cars.	自动驾驶汽车使用雷达和激光束进行导航。激光器安装在车顶，传感器安装在车体。雷达通过识别来自附近移动物体的无线电波反射来工作。即便在驾驶时，汽车也会持续发射射频波，这些射频波会被相邻物体和其他车辆反射回来。
To determine the distance between the car and the object, the reflection's time	为了确定车辆和物体之间的距离，需要记录反射的时间。根据雷达

is noted. On the basis of the radar data, the appropriate action is then conducted. By identifying radio wave reflections from nearby objects, radar operates. On the basis of the radar data, the appropriate actions are then done. Radar operates by spotting radio wave refractions from nearby moving objects [20].	数据，采取适当的操作。雷达通过识别来自附近物体的无线电波反射来工作，根据雷达数据，采取适当的操作。雷达通过探测周围移动物体的无线电波折射来工作。
4.7 Advantages of Autonomous Vehicles	4.7 自动驾驶汽车的优势
Self-driving automobiles, which are highly automated technology, provide a number of potential advantages.	自动驾驶汽车作为高度自动化的技术，具有许多潜在的优势。
·Improved road safety	• 提高道路安全
Automated systems could minimize the number of crashes in the roadways. As per government data,94%of accidents are caused by the actions or missteps of drivers. AVs can help minimize errors by drivers. Drivers with greater autonomy may be less likely to be involved in dangerous and hazardous driving practices. The best hope is that distracted driving, accelerating, intoxicated driving, unbuckled car occupants, and stoned driving will be lowered.	自动化系统可以最大程度地减少道路上的车祸次数。根据政府数据，94%的事故是由驾驶员的行为或失误导致。自动驾驶汽车可以帮助降低驾驶员的失误。具有更大自主性的驾驶员可能更不容易参与危险和有害的驾驶行为。最好的希望是分心驾驶、加速驾驶、酒后驾驶、不系安全带、药酒驾驶的情况将会减少。
· Enhanced Independence	• 增强独立性
Personal freedom is increased with full automation. People who are blind are	全自动化提高了个人的自由。盲人可自给自足，高度自动化的汽车可

self-sufficient, and heavily automated cars can help them live the lives needed by them. Seniors' freedom could be improved by these cars. Highly autonomous vehicle (HAV) ride-sharing can make personal transportation less expensive and increase traversal.	以帮助他们过上需要的生活。这些汽车可提高老年人的自由度，高度自主驾驶汽车（HAV）共乘服务可以降低个人交通成本，增加出行便利性。
· Saving cash	• 省钱
Automated driving methods may have a number of financial implications for us. HAVs can help to reduce collapse-related expenditures such as medical costs, productivity loss, and car repairs. Less accidents may result in lower insurance prices.	自动驾驶方法可能对我们有一系列财务影响。高度自主驾驶汽车可以帮助减少与事故相关的支出，如医疗费用、生产力损失以及汽车维修费用。事故减少可能会导致保险价格下降。
· More Efficiency	• 高效
The widespread use of HAVs might enable time travel for drivers. In the upcoming years, HAVs may make it easier to drop off travelers at their desired location, whether it's an airport or a shopping complex, while the vehicle itself parks. In a totally automated car, all passengers could safely take part in more useful or enjoyable tasks such as responding to emails or watching a film.	广泛使用高度自主驾驶汽车可能会为驾驶员创造出时间。在未来几年，高度自主驾驶汽车可能会让旅客更容易到达想去的地方，无论是机场还是购物中心，而车辆自身会自动停车。在全自动化汽车中，所有的乘客可以安全地参与到更有用或愉快的任务中，比如回邮件或看电影。
· Less Congestion	• 减少拥堵

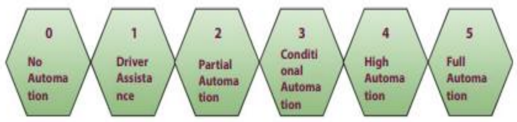
AVs could help with a variety of traffic congestion problems. When there are fewer collisions or fender benders, road backups are lowered. By maintaining a safe and consistent spacing between vehicles, HAVs help to reduce the frequency of stop-and-go waves that cause road congestion.	自动驾驶汽车可以帮助解决各种交通拥堵问题。如果碰撞或轻微刮蹭减少，道路拥堵就会缓解。通过保持车辆之间安全且一致的间距，高度自主驾驶汽车有助于减少引起道路拥堵的走走停停现象的频率。
· Gains for the environment	• 环境利益
AVs have the ability to reduce carbon emissions and consumption of fuel. Fuel is saved by lowered traffic, and HAVs reduce emissions of greenhouse gasses. Automation and carpooling may increase supply for all types of electric vehicles. The cost-effectiveness of electric vehicles is increased when the vehicle is used for longer hours each day [21].	自动驾驶汽车有能力减少碳排放和燃料消耗。减少交通可以节约燃料，高度自主驾驶汽车减少了温室气体的排放。自动化和拼车可能会增加各种类型电车的供应，一旦电车每日使用量增加，其成本收益也会提高。
4.8 Use Cases for Autonomous Vehicle Technology	4.8 自动驾驶车辆技术的应用案例
In a world where vehicle automation technology is widely used, there may be less traffic, safer roads, and linked cars that let drivers relax and enjoy the journey. The market for AV technology is expanding swiftly and is predicted, by 2026, to be $556.67 billion USD. The sector still has a way to go though. Technology for	在广泛应用车辆自动化技术的世界中，可能会有更少的拥堵，更安全的道路，以及让驾驶员放松并享受旅程的联网汽车。自动驾驶技术的市场正在迅速扩张，预计至 2026 年，将达到 5566.7 亿美元。不过，该领域仍有很长的路要走。自动驾驶车辆技

autonomous vehicles needs to cooperate with various fields in order to perform successfully. The following list includes the top 5.	术需要与各个领域合作，才能取得成功。下面列出了前五名。
4.8.1 Five Use Cases	4.8.1 5 项应用案例
· 5G	• 第五代移动通信技术（5G）
It is anticipated that an autonomous car will produce 2 Petabytes of data annually. If the greatest Wi-Fi was available, it would take months to transfer that much data. 5G speeds are 10 times quicker than 4G speeds and are practically real time. The future of self-driving vehicles is already achievable.	预计自动驾驶汽车每年将产生 2 百万亿拍字节的数据。如果最高速的 Wi-Fi 可用，传输这么多数据将需要几个月的时间。5G 的速度比 4G 快十倍，几乎是实时的。自动驾驶汽车的未来已经可以实现。
· Latency	• 时延
Reduced response time is yet another benefit of the 5G feature, which is advantageous for autonomous vehicles. When it comes to passenger safety, 4G's current time delay of 50ms is considered as a significant delay.	减少响应时间是 5G 功能的另一好处，对自动驾驶汽车非常有利。在乘客安全方面，当前 4G 的 50ms 延迟被认为是一个重大延迟。
·Smart cities and IoTs	• 智慧城市和物联网
A self-driving vehicle needs knowledge of its surroundings in order to make wise decisions. That is possible in IoT-ready smart cities. A self-driving automobile can go more shrewdly and	自动驾驶汽车需要了解其周围环境，以做出明智的决策。这在物联网准备就绪的智慧城市是可能的。如果城市可以报告交通、信号等情况，自动驾驶汽车在城市中行驶时可以更聪明、更轻松。

easily about town if the city can report on traffic, signals, etc.	
· Data Management	• 数据管理
It takes time to examine all of the data that a self-driving car generates. Edge computing can speed up this research by looking at information closer to the source because there could be nearly 10 million new cars on the road.	审查自动驾驶汽车生成的所有数据需要时间。因为将近有 1000 万辆新车上路，边缘计算可以通过查看信息源附近的信息加快这项研究。
· V2X	• 车辆与万物互联（V2X）
Data from automated vehicle sensor systems and other source materials can be transmitted over rising, elevated, and moderate channels—thanks to vehicle-to-everything (V2X) technology. Because of the ecosystem it creates, cars can communicate with one another and with infrastructure such as parking spaces and traffic lights. This not only improves car safety but also alerts passengers and drivers to impending roads, allowing them to react appropriately. An automated car would be capable of deciding for itself when paired with artificial intelligence (AI) [22].	自动驾驶车辆传感器系统以及其它信息来源的数据，可以通过不断发展的、提高的和中等的通道传输，这要归功于车辆与万物互联（V2X）技术。由于其创造的生态系统，让车辆可以彼此通信，也可以与停车位和交通灯等基础设施进行通信。这不仅提高了汽车的安全性，还可以提醒乘客和驾驶员即将到来的道路情况，让他们做出适当的反应。当与人工智能（AI）配对时，自动汽车能够自主决策。
4.9 Future Aspects of Autonomous Vehicles	4.9 自动驾驶汽车的未来方面

During the last 10 years, the public's fascination with autonomous cars has fueled collaboration between makers and the IT pioneers. How far we are from integrating automatic vehicles autonomous vehicle (AVs) to the systems for transportation? By 2030, 1 in 10 vehicles will be fully automated globally, according to projections, but until significant obstacles can be overcome, the industry can only make educated guesses. Before driver-less vehicles were a common sight on the highways, however, several parts of a very complex puzzle needed to fit together.	在过去的十年里，公众对自动驾驶汽车的迷恋推动了制造商和 IT 先驱之间的合作。我们离自动车辆整合到交通系统中还有多远？根据预测，到 2030 年，全球每 10 辆车中就会有 1 辆是完全自动化的，但在克服重大障碍之前，该行业只能做出合理猜测。然而，在无人驾驶汽车在公路上普遍出现之前，需要将非常复杂的几部分整合在一起。
The buzz surrounding AVs is still being fueled by real-world testing and exciting vehicle projects, but many automakers now recognize that developing technology is much more difficult than they initially believed. Nevertheless, confidence for 5G-enabled AI-powered automated driving technology is on the rise as advances in partially automated vehicles provide a realistic view of what the following decade may involve. What variables will contribute to the development of a self-driving future that	关于自动驾驶车辆的热潮仍在通过实地测试和令人兴奋的汽车项目推动，但许多汽车制造商现在意识到，开发技术比他们最初认为的困难得多。尽管如此，因为部分自动驾驶汽车的进步为未来十年的发展提供了预期，所以人们对 5G 赋能、人工智能驱动的自动驾驶技术的信心正在上升。哪些变量将有助于自动驾驶未来的发展，拥有彻底改变我们交通习惯到未来智能城市设计的能力？

have the ability to revolutionize everything from our transportation habits to the future design of smart cities?	
4.9.1 Levels of Vehicle Autonomy	4.9.1 车辆自主性级别
As a set of standards that serve as a benchmark for capabilities in AV, the Society of Automotive Engineers (SAE) has developed five phases of autonomy of the vehicle. They begin at Level 0 (Manual Balance) and progress to Level 5 (fully independent). With Tesla's automatic pilot system, which is divided as second level, the driver has to be prepared to take control while the car handles tasks such as steering and acceleration.	作为自动驾驶汽车能力的基准标准，汽车工程师协会（SAE）制定了车辆自主性的五个阶段。从 Level 0（手动平衡）开始，逐渐发展到 Level 5 级（完全自动化）。特斯拉的自动驾驶系统被划分为第二级，驾驶员需要做好准备接管控制，同时汽车负责转向和加速等任务。
For several years, Googles automated driving project Waymo has been escorting passengers around Phoenix using Level 4 autonomy. Automakers such as Ford are conducting a test to see how far autonomous technology can go in a fictitious city with the size of 24 football pitches in the University of Michigan's Mcity Test. Researchers are reading critical lessons about how autonomous and networked vehicles can be functioned in the controlled testing environment.	多年来，谷歌的自动驾驶项目 Waymo 使用 Level 4 自主性在凤凰城为乘客保驾护航。福特（Ford）等汽车制造商正在进行测试，以了解自动驾驶技术在密歇根大学 Mcity 测试中心占地 24 个足球场大小的虚构城市里能走多远。研究人员正在阅读有关自动驾驶汽车和联网汽车如何在受控测试环境中运行的关键课程。

 **Figure 4.2** Levels of vehicle autonomy.	0-无自动化 1-驾驶辅助 2-部分自动化 3-有条件自动化 4-高度自动化 5-完全自动化 图 4.2 车辆自动化等级
4.9.2 Safer Mobility Technology	4.9.2 更安全的移动技术
One of the primary goals of the autonomous vehicle industry is to provide a safe and secure journey for travelers, car owners, and bicyclists. Nine out of 10 collisions, as per the National Highway Traffic Safety Administration in the United States, are the output of human mistake. AVs do have the ability to replace humans in the bulk of traffic incidents if the technique is capable of living up to its words; nevertheless, they must initially depend on automated driving vehicles that can perceive better than the greatest human driver on the roadway.	自动驾驶车辆行业主要目标之一是为旅行者、车主和骑行者提供安全可靠的旅程。根据美国国家公路交通安全管理局的数据，10 起碰撞中有 9 起是由人为失误造成的。如果这项技术能够达到预期，自动驾驶汽车确实有能力在大部分交通中取代人类。然而，它们最初必须依赖那些感知能力比道路上最优秀的人类驾驶员还要强的自动驾驶汽车。
Data will obviously be essential for maximizing the potential of AVs. The ongoing progression of safety systems sets the stage for future development of intelligent autonomous systems capable of navigating major roads with minimal or no	数据显然对最大化自动驾驶汽车的潜力至关重要。不断进化的安全系统为未来智能自助系统的发展奠定了基础，这些系统能够在最少或没有任何生物干预的情况下在主要道路上行驶。ADAS，俗称高级驾驶辅

living creature intervention. ADAS, commonly known as advanced driver assistance systems, which is common in modern automobiles, utilizes sensing devices including such sensor and laser scanners to identify an object and becomes advanced in the new generation. Deployment of AVs will always be successful to the extent that the 5G technologies enable artificial intelligence and observational abilities in self-driving vehicles.	助系统，在现代汽车中很常见，利用传感器和激光扫描仪等感知设备识别物体，并在新一代中变得更先进。只要 5G 技术在自动驾驶汽车中实现了人工智能和观测能力，自动驾驶汽车的部署一定会成功。
4.9.3 Industry Collaboration and Policy Matters	4.9.3 产业合作和政策事项
It might take long-term cooperation among government agencies, automakers, tech innovators, telecoms, and others to innovate cars for the future. As competition is advancing in the scene, the disabilities are very costly and complex for any one side to manage on its own. Progression is made in China where there is a very high level of private-public support for autonomous car technologies. By 2030, a journey service in China, Didi, intends to apply more than a hundred thousand robotaxis across its launch pad, and a surge in the commercialization of	可能需要政府机构、汽车制造商、科技创新者、电信公司等长期合作，为未来的汽车创新。随着竞争的加剧，任何一方，单独解决这些障碍非常昂贵和复杂。中国取得了进展，因为私营部门和公共部门对自动驾驶汽车技术提供了极高水平的支持。到 2030 年，中国的出行服务公司滴滴，计划在其启动平台上应用超过 10 万量机器人出租车，同时，管理自动驾驶汽车开发的新法规推动了自动驾驶汽车商业化的激增。

autonomous vehicles is being fueled by new regulations governing AV development.	
Consumers are ready for driverless automobiles despite the considerable challenges that lie ahead. When industry participants and experts concur that AVs do have the ability to alter mobility, making predictions of what should happen within commercialization gets harder. If the automotive industry is to advance over the next 10 years, problems with many layers will be overcome in upcoming generations of technological advancements [23].	尽管未来面临巨大的挑战，但消费者已经准备好迎接无人驾驶汽车。要是行业参与者和专家都认同自动驾驶汽车确实能改变出行方式，那么对商业化进程中的情况进行预测就更难了。如果汽车行业要在未来十年取得进步，需要克服许多层面的问题，并不断推动新一代的技术进步。
In order to usher in an autonomous future, vehicles and other transportation systems are now being researched and developed. A technologically advanced driverless society is on the horizon. Further technological advances will result from these developments in AVs. On the basis of Internet of Vehicle (IoV) and VANETs, numerous applications have already been suggested. Powerful next-generation infrastructures may now be built—thanks to developments in IoV, acting as an interface to link various items to the	为了迎接自动驾驶的未来，车辆和其他交通系统正在进行开发和研究。一个技术先进的无人驾驶社会即将到来。这些自动驾驶汽车的发展将带来进一步的技术进步。基于车联网（IoV）和车辆自组织网络（VANETs），已经提出了许多应用。得益于 IoV 的发展，强大的下一代基础设施可以构建，将各种物品连接到网络，包括执行器、传感器和完整车车。随着基于物联网的智慧城市的发展，人们正在研究像 BCG 这样，通

Internet, including actuators, sensors, and complete vehicles. As smart cities based on IoT are being developed, research is being done on technologies like BCG to disseminate content through cloud support. An IoV-based technology is called VANETs.	过云支持来传播内容的技术。基于车联网的技术被称为 VANETs。
Its main responsibility is to provide constant connectivity to resources like the Internet. The number of users on the Internet has expanded due to its quick development, and VANETs can be utilized to meet their demands by enabling mobile access to resources and Internet connectivity. It also had potential applications in other industries like intelligent transportation systems, military systems, and health and safety, to mention a few. In order to maintain an adaptable strategy in monitoring traffic and pollutant density, VANET enables us to cluster cars according to routing, mobility, and driving habits. The AVs will be able to choose routes more appropriately with the aid of this knowledge.	其主要责任是为互联网等资源提供持续的连接。由于互联网的快速发展，互联网用户的数量不断增加，而 VANETs 可以通过实现移动访问资源和互联网连接来满足用户需求。它还在其他行业中具有潜在应用，如智能交通系统、军事系统、健康与安全等领域。为了保持在监控交通和污染物密度方面的灵活策略，VANET 使我们能够根据路线、移动性和驾驶习惯对汽车进行分组。有了这些信息，自动驾驶汽车能够更加恰当地选择路线。
Once government agencies have legalized vehicle-to-vehicle communication and all vehicles on the	使用车载自组织网络（VANET）进行跟踪、导航、路由和通信的好处只有在以下两个前提下才更加明显：

road have adapted to this technology, the benefits of using VANET for tracking, navigating, routing, and communication will become more obvious. According to the study, since there are effective cellular or LTE communication channels between roadside devices and the cloud platform, radio frequency identification should be used by moving cars and roadside units for vehicle-to-infrastructure communication.	一是在政府机构批准车对车通信合法化，二是道路上所有车辆都适应了这项技术。研究显示，鉴于路边设备与云平台之间存在有效的蜂窝或长期演进（LTE）通信信道，移动车辆和路边单元应采用射频识别技术进行车与基础设施之间的通信。研究显示，射频识别技术将对医疗保健行业产生巨大影响，还可用于车对车通信。
According to the study, it will have a huge impact on the healthcare industry and can also be utilized for vehicle-to-vehicle communication. The paper proposes a novel routing algorithm based on collaborative learning for information delivery to the target, throughput maximization, and delay minimization. In the event that there were more cars on the road and there was network route congestion, this technology would aid vehicular sensor networks (VSNs). The learning automata swiftly decide on a route based on past experience and the nearby access points.	研究显示，射频识别技术将对医疗保健行业产生巨大影响，还可用于车对车通信。该文提出了一种基于协作学习的新型路由算法，用于信息传递给目标、最大化吞吐量和最小化延迟。如果道路上的车辆增多，并且网络路由拥挤，该技术将有助于车载传感器网络（VSNs）。学习自动机根据过去经验和附近访问点快速决定路线。
4.10 Summary	4.10 结语
In conclusion, even if autonomous vehicles appear to be a distant concern for	总之，即使自动驾驶汽车对当前道路使用者来说似乎是一个遥远的

present road users, global tests of vehicles in motion indicate that public cars may soon be available. Another revolution will undoubtedly result from these changes in transportation, so it is critical to inform the public about how to handle autonomous vehicles. This instruction should cover proper conduct on the roadways where the vehicles would be able to move. However, it is crucial to educate the general public with the applied nomenclature and the division of vehicles owing to the degree of autonomous driving before cars are fully integrated into the existing transportation systems.	关注点，但在全球范围内进行的运行车辆测试表明，公共汽车可能很快就会问世。这些交通变革无疑会引发另一场革命，因此，向公众告知如何处理自动驾驶汽车至关重要。这项指导应包括在车辆可以行驶的道路上的适当行为准则。然而，在汽车完全融入现有交通系统之前，向普通大众介绍应用的术语和根据自动驾驶程度划分车辆是至关重要的。
Fully autonomous vehicles such as buses, lorries, and cars that can travel across large expanses of territory without the involvement of drivers would revolutionize ground transportation. Accidents and fatalities could be reduced significantly. Humans may utilize the time they spend trapped in traffic to accomplish assigned work or for recreation.	全自动驾驶汽车，如公共汽车、卡车和汽车，能够在没有驾驶员参与的情况下穿越大片领土，这将彻底改变地面交通。事故和死亡人数可能会显著减少。人们可以利用被困在交通堵塞中的时间完成分配的工作或进行娱乐活动。
The environment might reshape, requiring so little car park while increasing productivity and safety for everyone. Robotic vehicles would seamlessly	环境可能会重塑，需要更少的停车场，同时提高了每个人的生产力和安全性。机器人车辆将按需不间断地运输人员和物品到世界各地，从而导

transport people and products throughout the world on demand, resulting in the emergence of new models of business for distribution commodities and services—the “Physical Internet.” We might also observe human drivers freed from the demands on their attention that come with driving, free to travel far larger distances and jam up the roads and pollute the air.	致了分销商品和服务的新商业模式出现——“物理互联网”。我们还可以看到，人类驾驶员从驾驶所带来的注意力需求中解放出来，自由地行驶更远的距离，避免堵塞道路和污染空气。
This issue is even more urgent given the negative effects on employment caused by the COVID-19 epidemic. COVID-19 has worsened the disparities in mobility and employment that already exist in cities and has hurt ride-sharing and public transportation. Due to rise in e-commerce, robotic package delivery is becoming more popular, and more people are now working from home. Safe and effective public transit will continue to be essential for our communities as commuter, educational, and shopping habits shift toward a new normal. More than ever, investments in workforce training are required to guarantee that COVID-19-affected workers can participate in automated transportation systems in the future,	鉴于新冠疫情对就业造成的负面影响，这一问题变得更加紧急。新冠疫情加剧了城市中已经存在的流动性和就业差距，并对顺风车和公共交通造成了伤害。由于电子商务的兴起，机器人包裹递送变得越来越流行，越来越多的人现在在家工作。由于通勤、教育和购物习惯向新常态的转换，安全有效的公共交通将继续对我们的社区至关重要。比以往任何时候都更需要对劳动力培训进行投资，以确保受新冠疫情影响的工人能够参与未来的自动化交通系统中，无论这个未来多久才能实现。

however long that future takes to materialize.	

注：划线部分为报告正文中选取的案例。