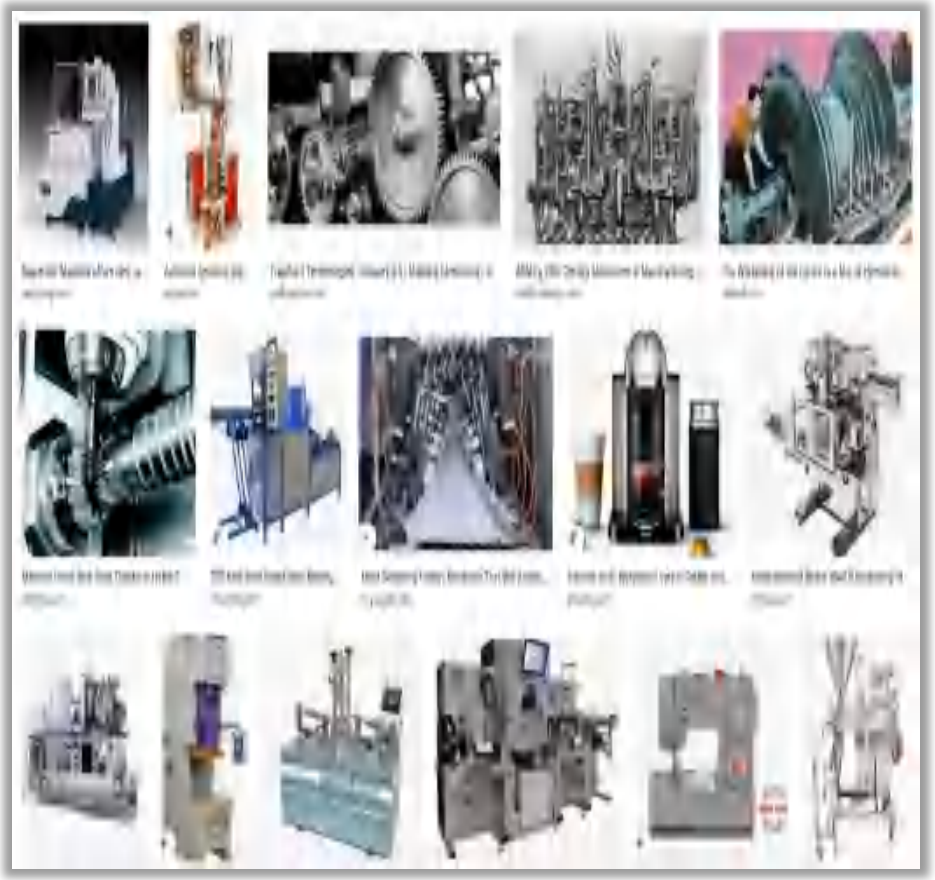
机器学习导论

第一章 绪论

提纲

- 机器学习的定义
- 机器学习究竟是什么
- 机器学习能做什么
- 机器学习与其它学科的关系
- 前沿机器学习期刊和会议
- 机器学习的历史和可能的未来

机器? 学习？



机器

学习

机器学习是啥?

机器学习（Machine Learning）

机器学习是人工智能的核心研究领域，是实现智能化的关键

经典定义：利用经验改善系统自身的性能

经验 → 数据

随着该领域的发展，目前主要研究智能数据分析的理论和算法，并已成为智能数据分析技术的源泉之一

图灵奖连续授予在该方面取得突出成就的学者

Leslie Valiant
(1949 -)
(Harvard Univ.)
“计算学习理论”奠基人

2010 年度

Judea Pearl
(1936 -)
(UCLA)
“图模型学习方法”先驱

2011 年度

机器学习（Machine Learning）

机器学习是人工智能的核心研究领域，是实现智能化的关键

经典定义：利用经验改善系统自身的性能

经验 → 数据

随着该领域的发展，目前主要研究智能数据分析的理论和算法，并已成为智能数据分析技术的源泉之一

图灵奖连续授予在该方面取得突出成就的学者

深度学习的贡献
获2018年度图灵奖

机器学习（Machine Learning）

人类学习：利用经验不断提高性能

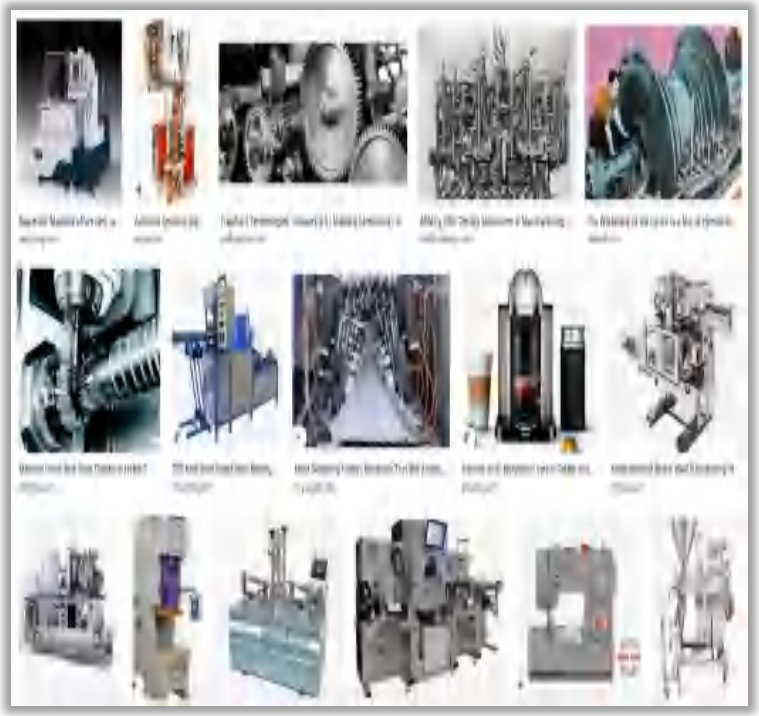
机器（计算机）如何学习？

机器问：经验是啥？我只会处理0，1

数据

经验 =》数据？

机器? 学习？



机器 → 数据 ⟷ 经验 ← 学习

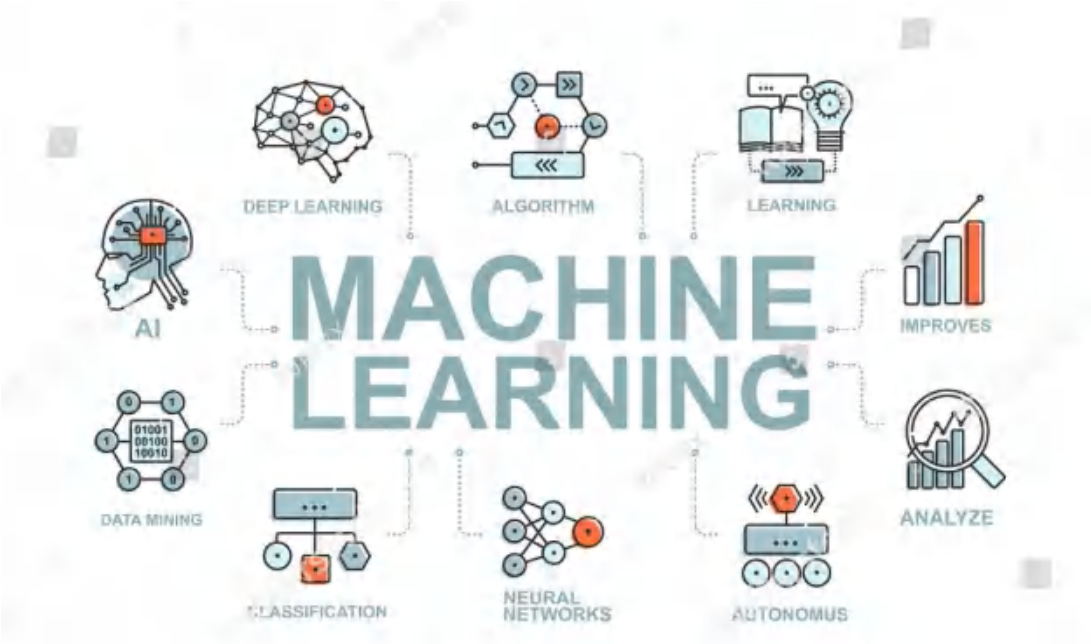
（计算机）　　（人类学习）

机器学习：以数据为经验的载体，利用经验数据不断提高性能的计算机系统/程序/算法

机器学习

机器学习：以数据为经验的载体，利用经验数据不断提高性能的计算机系统/程序/算法

广袤的交叉学科　　内容非常丰富（多彩）



机器学习

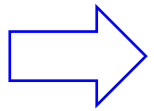
本课程:

第一部分：基本术语（第2章）

第二部分：经典算法（3-10章）

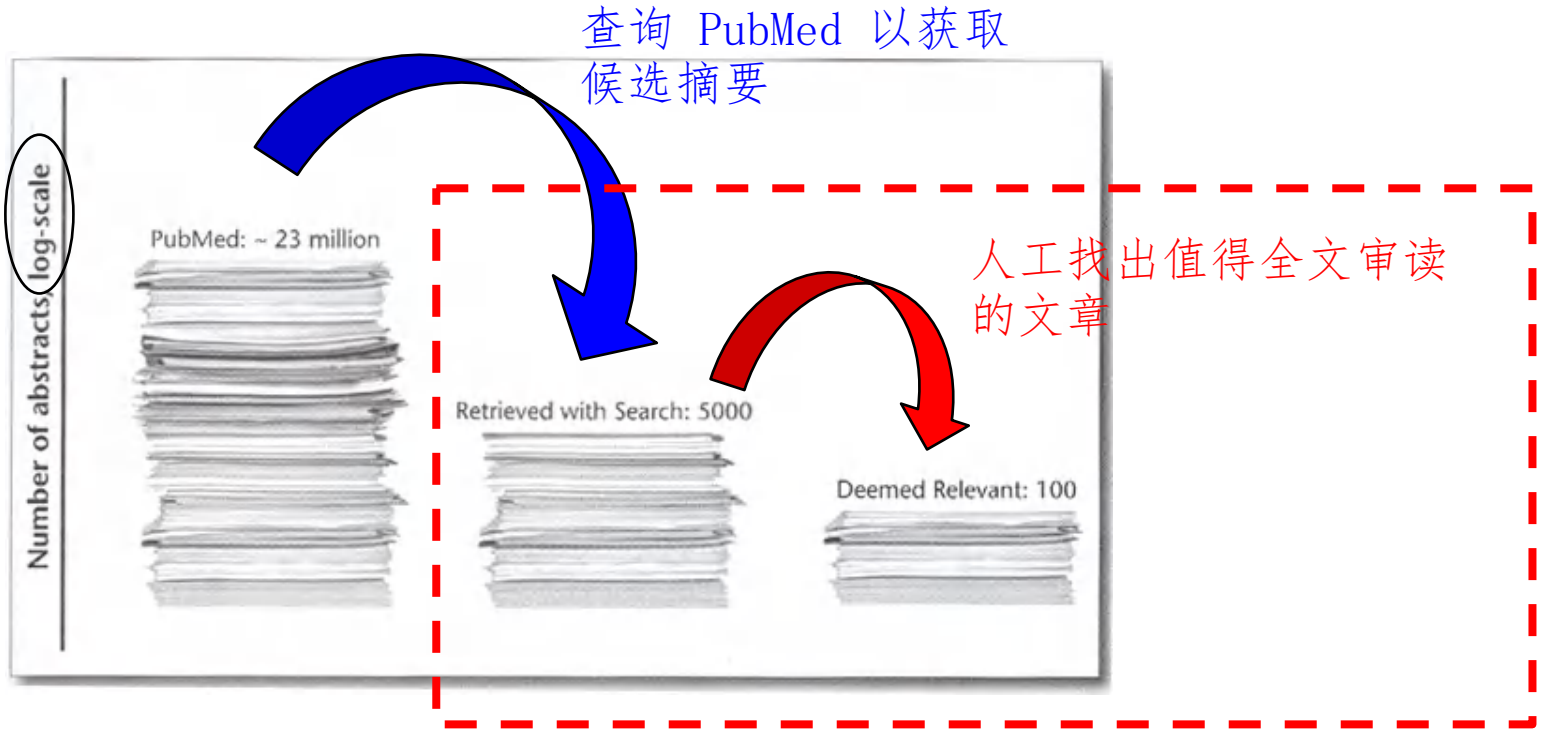
熟悉/了解/掌握机器学习经典算法

机器学习究竟是什么？

先看例子 

“文献筛选”

在“循证医学”（evidence-based medicine）中，针对特定的临床问题，先要对相关研究报告进行详尽评估



出自 [C. Brodley et al., AI Magazine 2012]

“文献筛选”

在一项关于婴儿和儿童残疾的研究中，美国Tufts医学中心筛选了约 33,000 篇摘要

尽管Tufts医学中心的专家效率很高，每篇摘要筛选时间只需 30 秒钟，但该工作仍花费了 250 小时

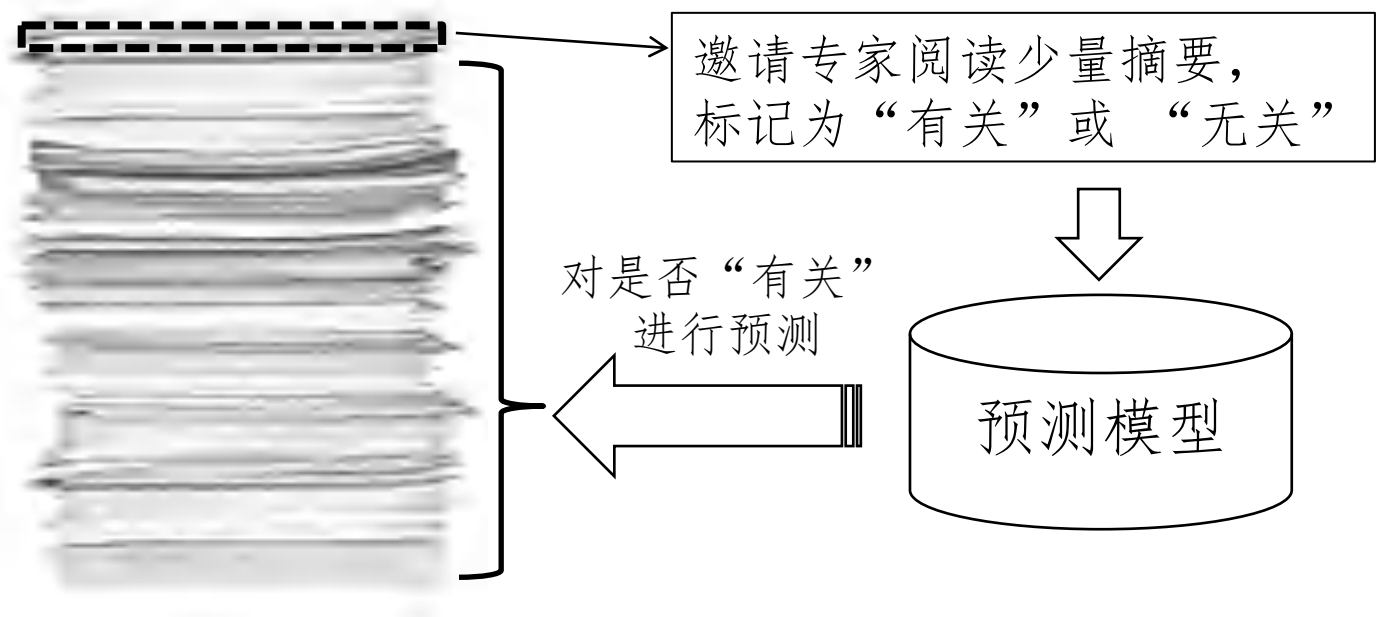
A portion of the 33,000 abstracts

每项新的研究都要重复这个麻烦的过程！

需筛选的文章数在不断显著增长！

“文献筛选”

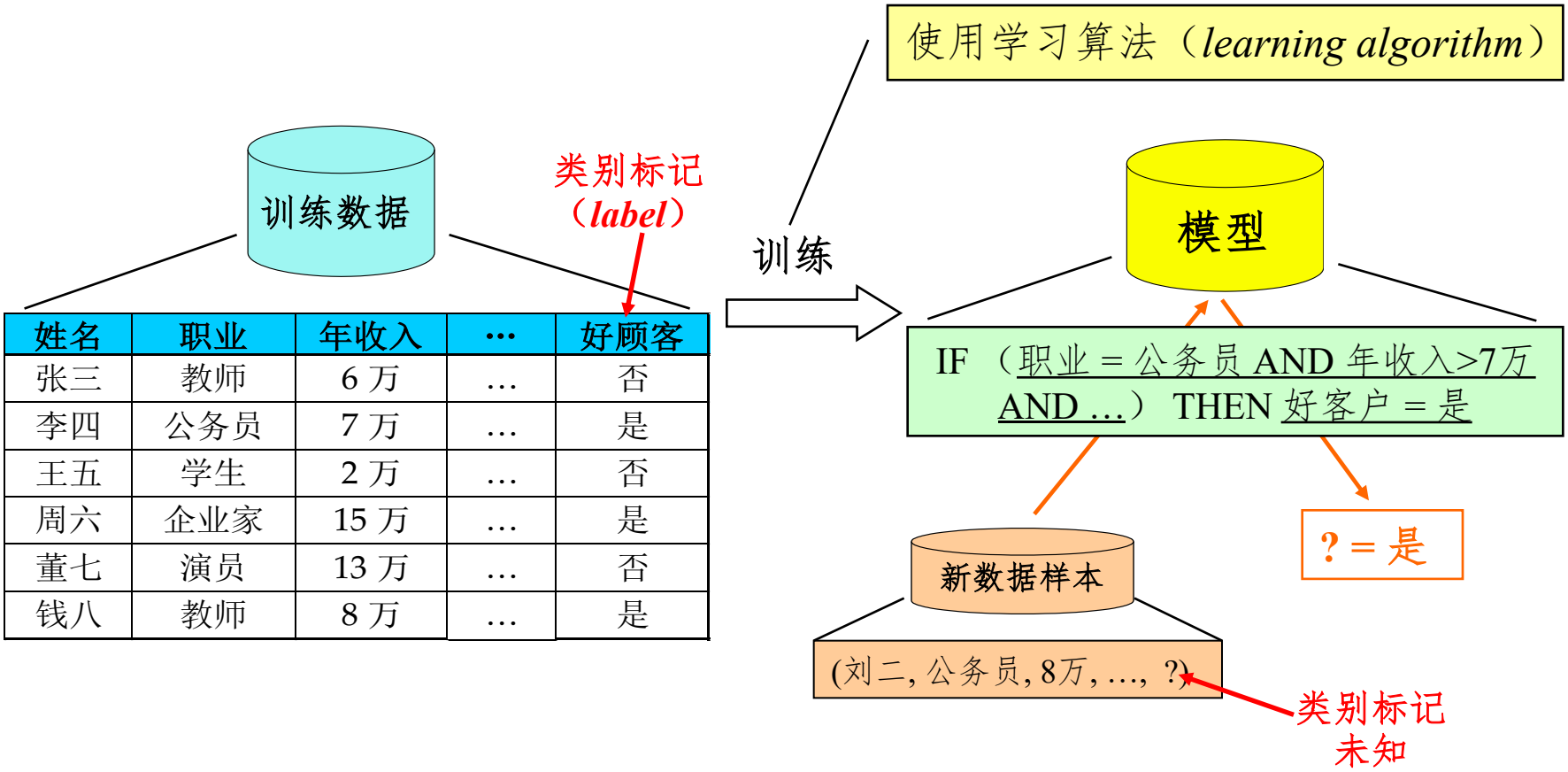
为了降低昂贵的成本，Tufts医学中心引入了**机器学习**技术



- 人类专家只需阅读 50 篇摘要，系统的自动筛选精度就达到 93%
- 人类专家阅读 1,000 篇摘要，则系统的自动筛选敏感度达到 95%

人类专家以前需阅读 33,000 篇摘要才能获得此效果

典型的机器学习过程


使用学习算法（learning algorithm）
训练数据
类别标记
（label）
训练
模型
姓名 职业 年收入 … 好顾客
张三 教师 6 万 … 否
李四 公务员 7 万 … 是
王五 学生 2 万 … 否
周六 企业家 15 万 … 是
董七 演员 13 万 … 否
钱八 教师 8 万 … 是
IF （职业 = 公务员 AND 年收入>7万 AND …） THEN 好客户 = 是
新数据样本
(刘二, 公务员, 8万, …, ?)
? = 是
类别标记
未知

机器学习与其它学科的关系

- 机器学习与数据挖掘
  - 数据挖掘：是指从海量数据中挖出知识（或不平凡，有价值的模式）、如尿布和啤酒等。
  - 联系：
    - 从定义上看，数据挖掘和机器学习都包括数据分析
  - 区别：
    - 机器学习、数据库、统计学是数据挖掘的关键支撑技术

机器学习与其它学科的关系

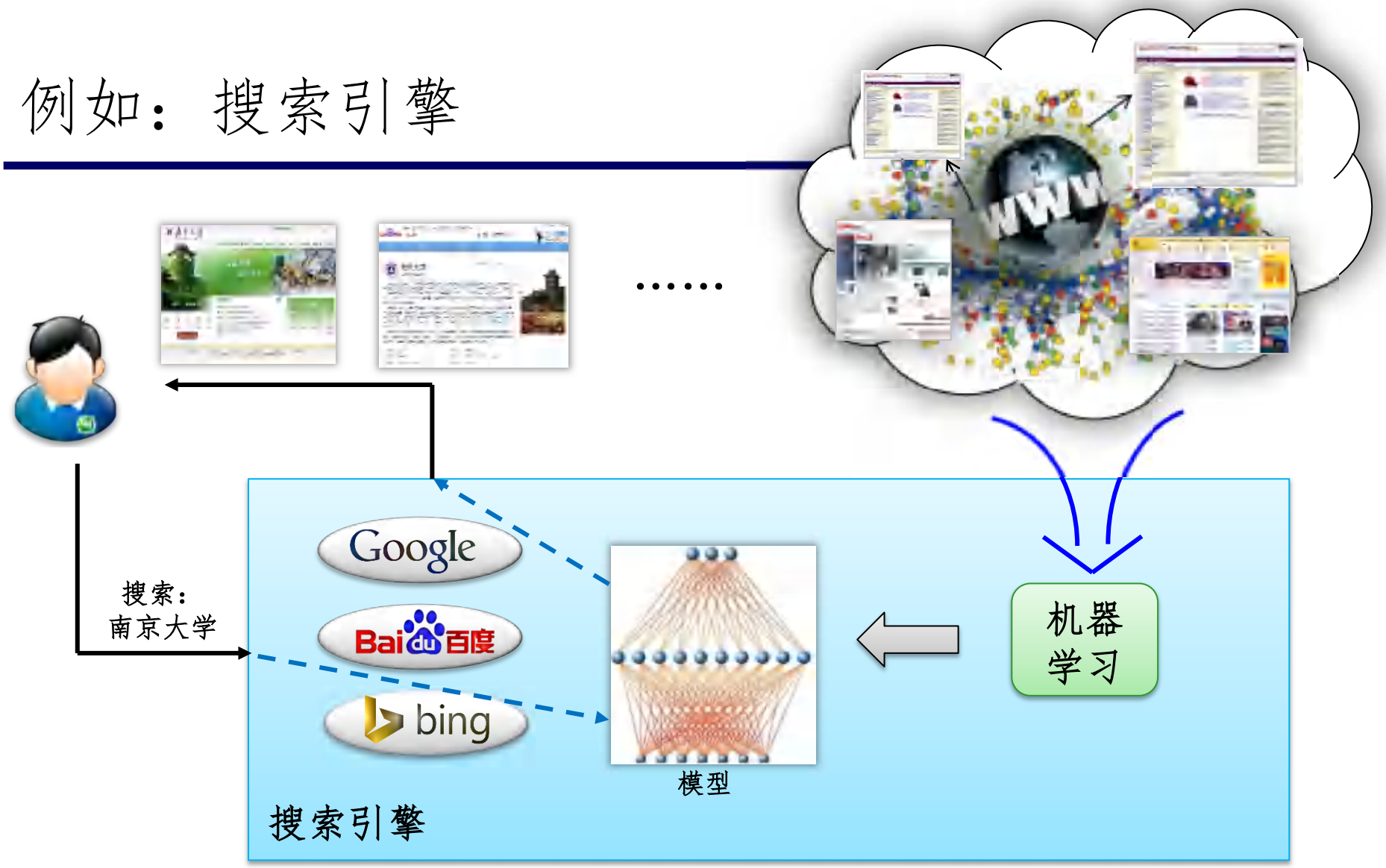
- 机器学习与大数据
  - 大数据研究：收集、存储、传输、管理大数据等
  - 联系：
    - 从定义上看，大数据研究和机器学习都包括数据分析
  - 区别：
    - 大数据研究目的是为了利用大数据，没有机器学习提供数据分析技术，大数据利用无从谈起

关键：如何将经验
表示成数据

机器学习能做什么？

我们可能每天都
在用机器学习

例如：搜索引擎



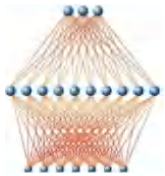
机器学习技术正在支撑着各种搜索引擎

例如：自动汽车驾驶

车载摄像头

车载雷达

机器学习



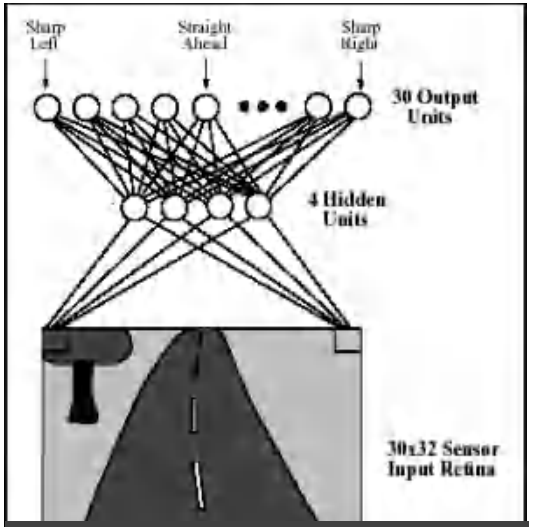
模型

方向盘旋转幅度

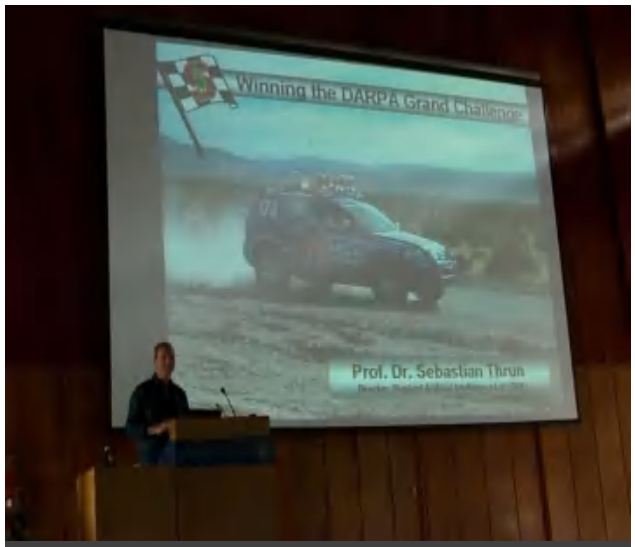
油门幅度

刹车幅度

控制汽车



美国在20世纪80年代就开始研究基于机器学习的汽车自动驾驶技术

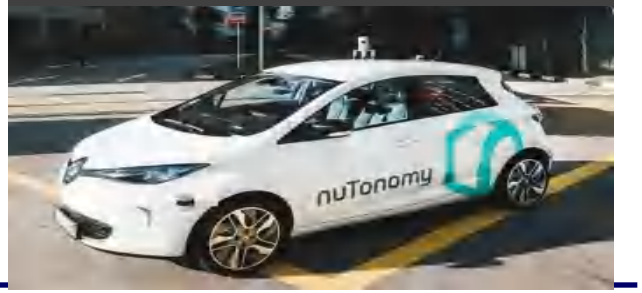


DARPA Grand Challenge - 2004

荒野中的无人车竞赛

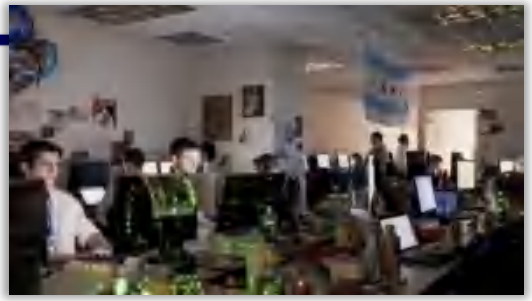
Google 无人驾驶汽车 - 2016

新加坡无人驾驶出租车 - 2016



例如：帮助奥巴马胜选

《时代》周刊



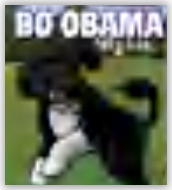
这个团队行动保密，定期向奥巴马报送结果；被奥巴马公开称为总统竞选的“核武器按钮”（“They are our nuclear codes”）

通过机器学习模型

◆ 个性化宣传

喜欢宠物？

奥巴马也有宠物！



喜欢篮球？

奥巴马也是篮球迷！

◆ 广告购买

精准定位不同选民群体，建议购买冷门广告时段，广告资金效率比2008年提高14%

◆ 筹款

和乔治克鲁尼/奥巴马共进晚餐对于年龄在40-49岁的美西地区女性颇具吸引力…… 乔治克鲁尼为奥巴马举办的竞选筹资晚宴成功募集到1500万美元

例如：AlphaGO

计算/预测出较高胜率的走法？

大量棋谱如何生成/利用

意义重大，公开的计算难题；

影响深远，熟知的日常游戏

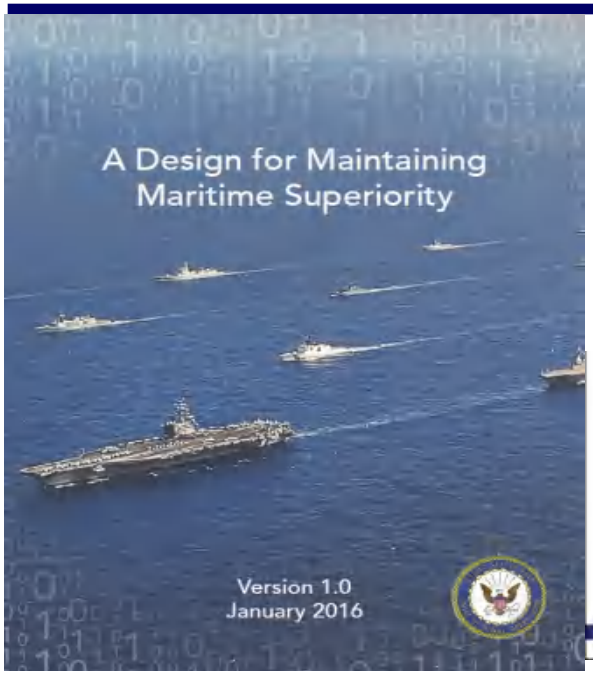
例如：视频理解

如何让计算机理解视频？

从0-1到语义表达

Describes without errors	Describes with minor errors	Somewhat related to the image	Unrelated to the image
			
A person riding a motorcycle on a dirt road.	Two dogs play in the grass.	A skateboarder does a trick on a ramp.	A dog is jumping to catch a frisbee.
			
A group of young people playing a game of frisbee.	Two hockey players are fighting over the puck.	A little girl in a pink hat is blowing bubbles.	A refrigerator filled with lots of food and drinks.
			
A herd of elephants walking across a dry grass field.	A close up of a cat laying on a couch.	A red motorcycle parked on the side of the road.	A yellow school bus parked in a parking lot.

例如：美军海权纲领性文件

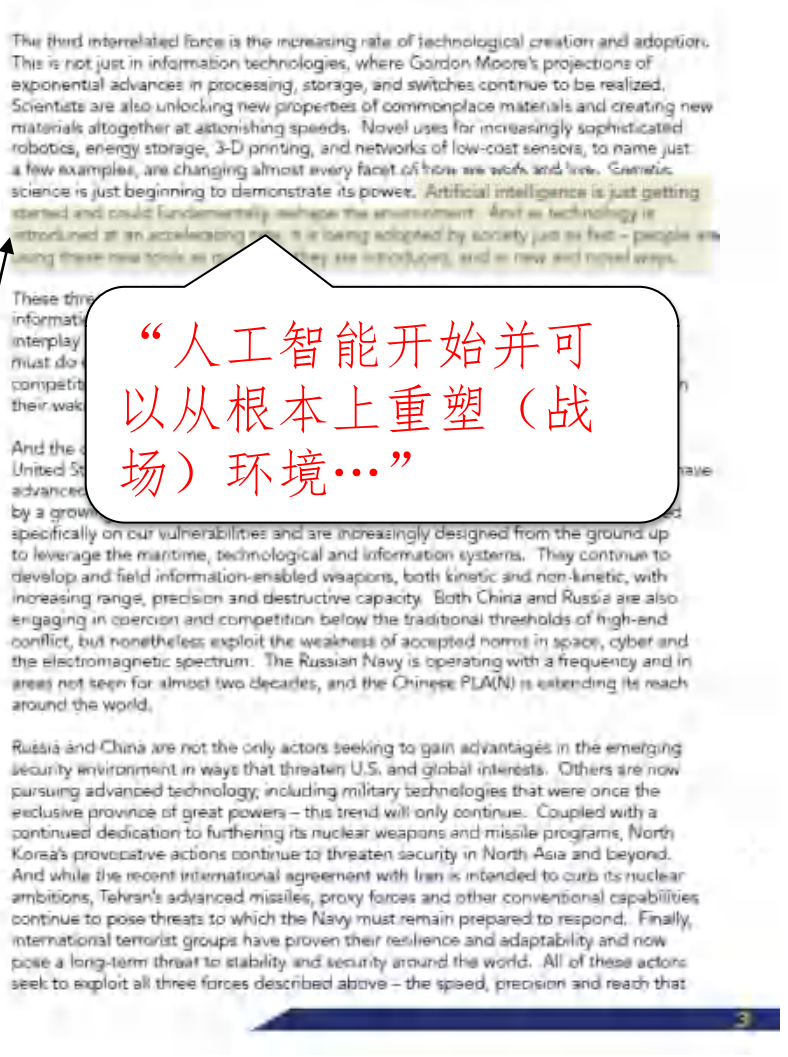



Conclusion

We will remain the world's finest Navy **only** if we all fight each an
better. Our competitors are focused on taking the lead – we mu
deny them. The margins of victory are razor thin – but decisive
integrity, accountability, initiative, and toughness to execute the
in this Design, execute our mission, and achieve our end state. I
to lead you.

JOHN M. RICHARDSON

8


The third interrelated force is the increasing rate of technological creation and adoption. This is not just in information technologies, where Gordon Moore's projections of exponential advances in processing, storage, and switches continue to be realized. Scientists are also unlocking new properties of commonplace materials and creating new materials altogether at astonishing speeds. Novel uses for increasingly sophisticated robotics, energy storage, 3-D printing, and networks of low-cost sensors, to name just a few examples, are changing almost every facet of how we work and live. Genetic science is just beginning to demonstrate its power. Artificial intelligence is just getting started and could fundamentally reshape the environment. And as technology is introduced at an accelerating rate, it is being adopted by society just as fast – people are using these new tools as they are introduced, and in new and novel ways.

These thr
informati
interplay
must do
competit
their wea

And the
United St
advanced
by a grow

specifically on our vulnerabilities and are increasingly designed from the ground up to leverage the maritime, technological and information systems. They continue to develop and field information-enabled weapons, both kinetic and non-kinetic, with increasing range, precision and destructive capacity. Both China and Russia are also engaging in coercion and competition below the traditional thresholds of high-end conflict, but nonetheless exploit the weakness of accepted norms in space, cyber and the electromagnetic spectrum. The Russian Navy is operating with a frequency and in areas not seen for almost two decades, and the Chinese PLA(N) is extending its reach around the world.

Russia and China are not the only actors seeking to gain advantages in the emerging security environment in ways that threaten U.S. and global interests. Others are now pursuing advanced technology, including military technologies that were once the exclusive province of great powers – this trend will only continue. Coupled with a continued dedication to furthering its nuclear weapons and missile programs, North Korea's provocative actions continue to threaten security in North Asia and beyond. And while the recent international agreement with Iran is intended to curb its nuclear ambitions, Tehran's advanced missiles, proxy forces and other conventional capabilities continue to pose threats to which the Navy must remain prepared to respond. Finally, international terrorist groups have proven their resilience and adaptability and now pose a long-term threat to stability and security around the world. All of these actors seek to exploit all three forces described above – the speed, precision and reach that

3

“人工智能开始并可以从根本上重塑（战场）环境…”

美海军作战部长John Richardson 2016年初签署的《保障制海权规划》中明确指出人工智能的重要

例如：战场战术层面 （美）

眼镜蛇系统：

Coastal Battlefield Reconnaissance and Analysis (COBRA)

用于频海战斗舰，执行无人空中战术侦察。在两栖攻击之前，于海浪区和海滩区探测和定位雷区和障碍物

http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=1237&ct=2

http://www.navysbir.com/n15_1/N151-049.htm

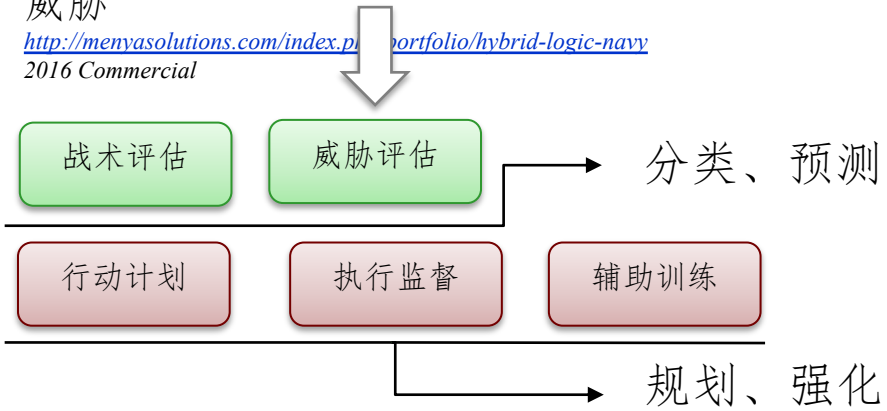
2015 US Navy Official

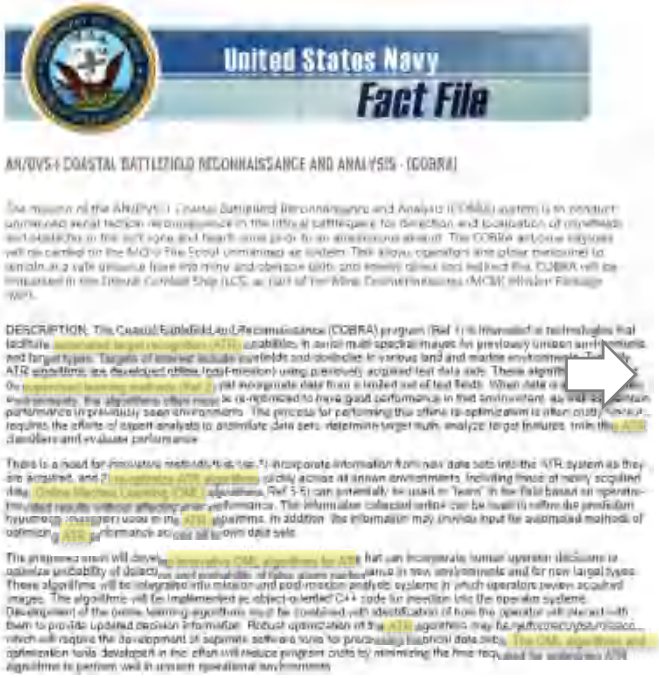
HybridLogic Navy:

一套自动的基于机器学习的代理，帮助人类和无人机理解战术状况，及时做出最佳决策，以对付海军作战中的威胁

http://menyasolutions.com/index.php/portfolio/hybrid-logic-navy

2016 Commercial





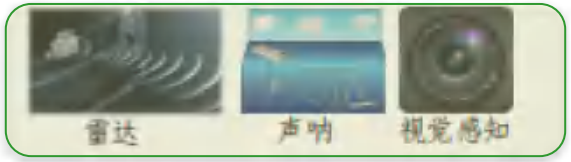
自动目标识别、监督学习以及在线学习技术被作为核心技术并多次提及

例如：战场战术层面 （英）

无人侦察快艇:

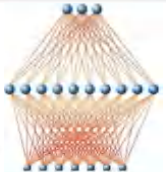
无人控制的情况下以50公里时速追踪快速目标并自动避障，进行跟踪、监视和间谍活动，或者用于海岸巡逻

http://www.telegraph.co.uk/news/2016/09/05/navy-unveils-robot-spy-speedboat/ *2016 Royal Navy Official /Commercial*



多源感知

机器学习



模型

控制模块

无人自动驾驶

船舶能源评估-条件优化和路由增强系统


Software to transform ship maintenance

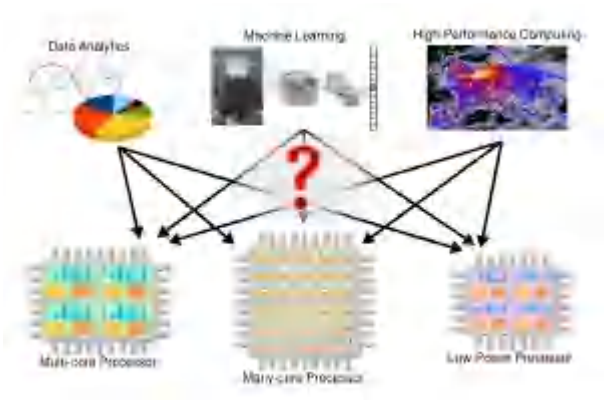
遗传算法以及其他一些机器学习方法用于获取追踪数据和确定舰船子系统关联的任务中

应对现代军舰日益复杂系统结构、针对其系统产生的海量数据而开发，能够有机组织军舰各个子系统，最终优化全舰效能

https://phys.org/news/2016-09-software-ship-maintenance.html

2016 Royal Navy Official / Commercial

例如：中长期战略层面 — 基础/技术研发

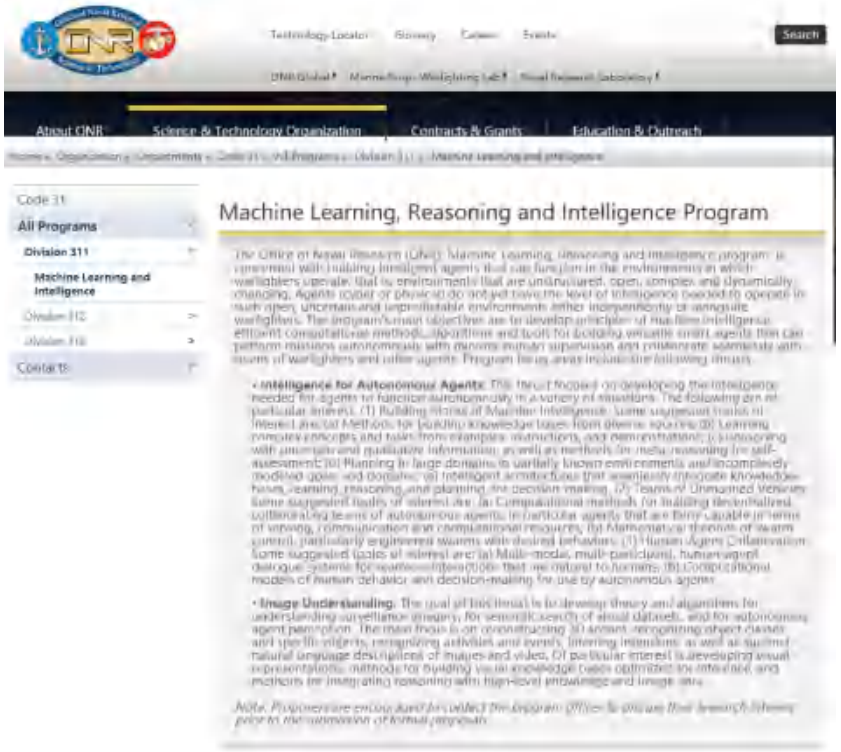


军用下一代机器学习处理器：

依托学习技术消除了海军开发人员选择架构的问题，由程序直接分析出最适合的处理器平台，最大化指令执行效率

http://futureforce.navylive.dodlive.mil/2017/07/popcorn-linux-software-for-a-diverse-world/

2017 US DOD Official



美海军研究院：

针对机器学习，特别对自主代理、图像理解展开全面研究

https://www.onr.navy.mil/en/Science-Technology/Departments/Code-31/All-Programs/311-Mathematics-Computers-Research/Machine-Learning-Reasoning-Intelligence

2017 US Navy Official / US Naval Research Division 311.

例如：中长期战略层面 — 关注、任命和表彰

美海军作战部长
John Richardson上将：

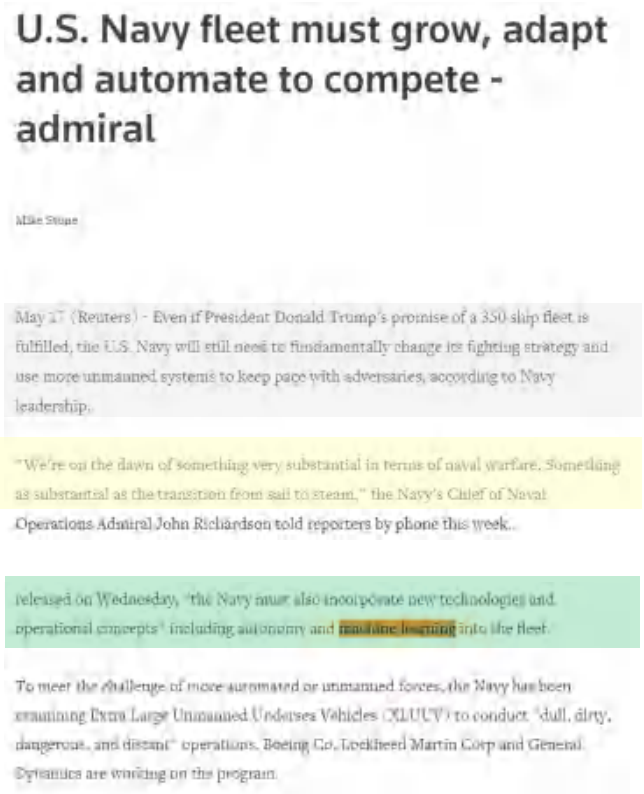
“就海战来说，我们正处于至关重要的拂晓（转折点）—就如同上次从人力到蒸汽机的那个变化一样重要”

据海军高层发言：即使特朗普总统承诺拥有350艘军舰，美国海军仍将需要从根本上改变其作战策略，并使用更多的无人系统来与对手保持步调一致。

“海军还必须将新技术和作战概念纳入到舰队中，包括自主和机器学习。”

http://www.reuters.com/article/usa-navy-fleet-idUSL2N1IH1R1

2017 Reuters Commercial



U.S. Navy fleet must grow, adapt and automate to compete - admiral

Mike Stone

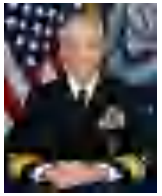
May 17 (Reuters) - Even if President Donald Trump's promise of a 350-ship fleet is fulfilled, the U.S. Navy will still need to fundamentally change its fighting strategy and use more unmanned systems to keep pace with adversaries, according to Navy leadership.

"We're on the dawn of something very substantial in terms of naval warfare. Something as substantial as the transition from sail to steam," the Navy's Chief of Naval Operations Admiral John Richardson told reporters by phone this week.

released on Wednesday, "the Navy must also incorporate new technologies and operational concepts" including autonomy and machine learning into the fleet.

To meet the challenge of more automated or unmanned forces, the Navy has been examining Extra Large Unmanned Undersea Vehicles (XLUUV) to conduct "dull, dirty, dangerous, and distant" operations. Boeing Co, Lockheed Martin Corp and General Dynamics are working on the program.

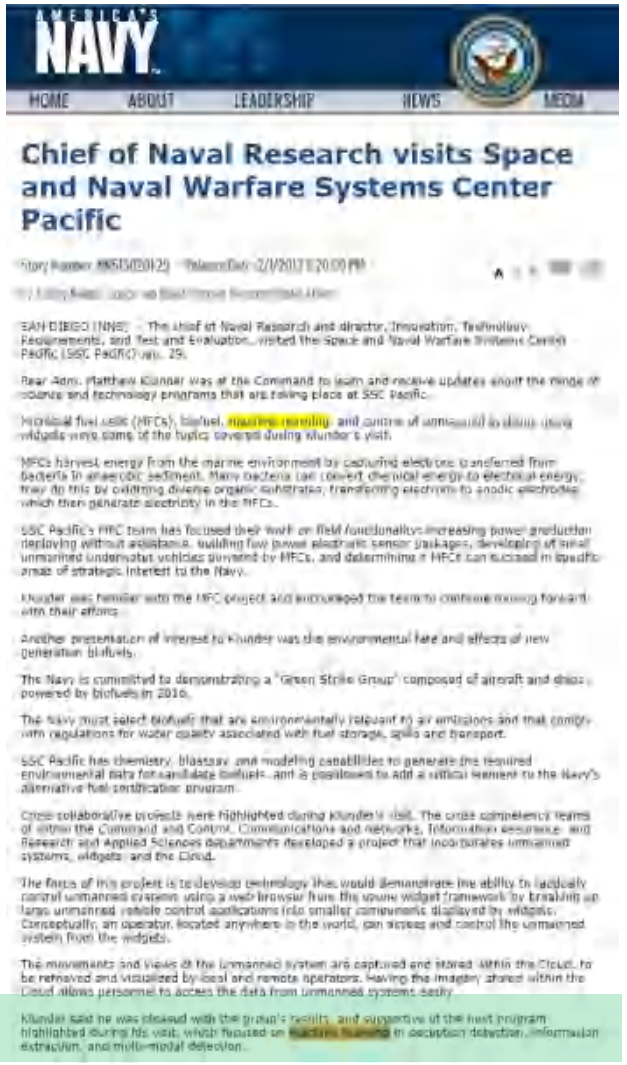
例如：中长期战略层面 —关注、任命和表彰



海军研究院主任
马修 克莱蒙少将：

（强调）“下一个计划，重点是机器学习在欺骗检测，信息提取和多模态检测方面...”

http://www.navy.mil/submit/display.asp?story_id=71818
US Navy Official



AMERICA'S NAVY

HOME ABOUT LEADERSHIP NEWS MEDIA

Chief of Naval Research visits Space and Naval Warfare Systems Center Pacific

SAN DIEGO (NNS) -- The chief of Naval Research and director, Innovation, Technology Requirements, and Test and Evaluation, visited the Space and Naval Warfare Systems Center Pacific (SSC Pacific) Jan. 25.

Rear Adm. Matthew Klunder was at the Command to learn and receive updates about the range of science and technology programs that are taking place at SSC Pacific.

Microbial fuel cells (MFCs), biofuel, machine learning, and control of unmanned systems using widgets were some of the topics covered during Klunder's visit.

MFCs harvest energy from the marine environment by capturing electrons transferred from bacteria in anaerobic sediment. Many bacteria can convert chemical energy to electrical energy; they do this by oxidizing diverse organic substrates, transferring electrons to anodic electrodes which then generate electricity in the MFCs.

SSC Pacific's MFC team has focused their work on field functionality-increasing power production, deploying without assistance, building low power electronic sensor packages, developing of small unmanned underwater vehicles powered by MFCs, and determining if MFCs can succeed in specific areas of strategic interest to the Navy.

Klunder was familiar with the MFC project and encouraged the team to continue moving forward with their efforts.

Another presentation of interest to Klunder was the environmental fate and effects of new generation biofuels.

The Navy is committed to demonstrating a "Green Strike Group" composed of aircraft and ships powered by biofuels in 2016.

The Navy must select biofuels that are environmentally relevant in air emissions and that comply with regulations for water quality associated with fuel storage, spills and transport.

SSC Pacific has chemistry, bioassay, and modeling capabilities to generate the required environmental data for candidate biofuels, and is positioned to add a critical element to the Navy's alternative fuel certification program.

Cross collaborative projects were highlighted during Klunder's visit. The cross competency teams of within the Command and Control, Communications and Networks, Information Assurance, and Research and Applied Sciences departments developed a project that incorporates unmanned systems, widgets, and the Cloud.

The focus of this project is to develop technology that would demonstrate the ability to tactically control unmanned systems using a web browser from the iWave widget framework by breaking up large unmanned vehicle control applications into smaller components displayed by widgets. Conceptually, an operator, located anywhere in the world, can access and control the unmanned system from the widgets.

The movements and views of the unmanned system are captured and stored within the Cloud, to be retrieved and visualized by local and remote operators. Having the imagery stored within the Cloud allows personnel to access the data from unmanned systems easily.

Klunder said he was pleased with the group's results, and supportive of the next program highlighted during his visit, which focused on machine learning in deception detection, information extraction, and multi-modal detection.

机器学习主要学术进展从哪得到

前沿学术期刊

- JMLR 《Journal of Machine Learning Research》
- TPAMI《IEEE Transactions on Pattern Analysis and Machine Intelligence》
- TKDE《IEEE Transactions on Knowledge and Data Engineering》
- TNNLS 《IEEE Transactions on Neural Network and Learning Systems》
- 国内：《中国科学 信息科学》
- …

前沿学术会议

- ICML (International Conference on Machine Learning)
- NeurIPS (Neural Information Processing Systems)
- KDD (ACM SIGKDD Conference on Knowledge Discovery and Data Mining)
- AAAI (AAAI conference on Artificial Intelligence)

机器学习是发展来的？到哪儿去?

简单介绍人工智能的历史

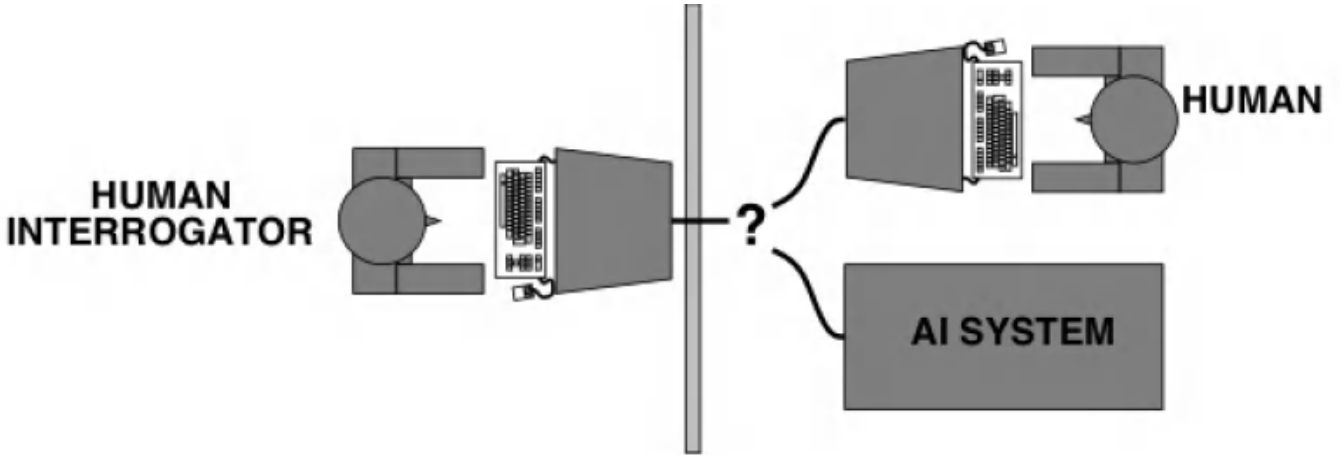
人工智能

1950

[Computing machinery and intelligence. Mind 49: 433-460, 1950.]

Alan Turing
1912-1954

Section 1: Imitation game (模仿游戏)



人工智能

AI

1950 *1956*

1956 Dartmouth 会议，命名 “Artificial Intelligence”

人工智能

AI

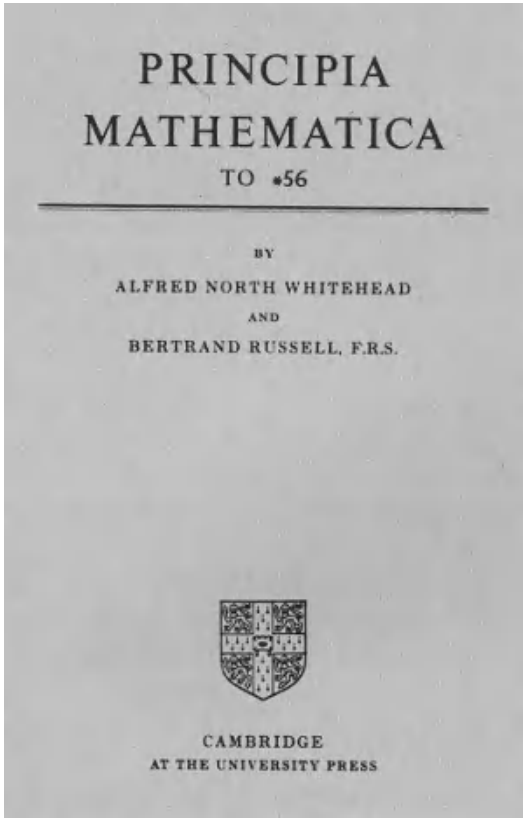
60–70
年代

1950 1956

逻辑学家

Allen Newell

Herbert Simon



“逻辑理论家”程序在1952 年证明了著名数学家罗素和怀特海的名著《数学原理》中的38 条定理；在1963 年证明了全部52条定理，特别值得一提的是，定理2.85 甚至比罗素和怀特海证明得更巧妙.

人工智能

AI

60-70 年代

80年代 初期

1950 1956

要使机器具有智能，就必须设法使机器拥有知识

Edward Albert Feigenbaum

专家系统

人工智能

由人来把知识总结出来再教给计算机是相当困难的，希望机器自己能够学习知识

AI

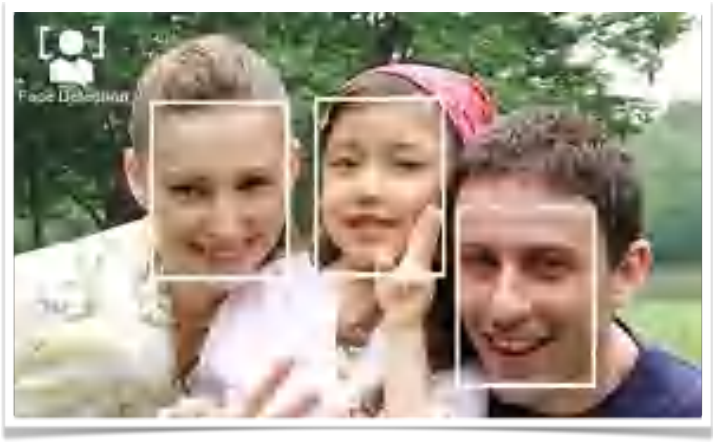
60-70 年代

80年代 初期

90年代 中期

1950 1956 2006

机器学习



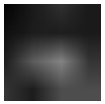
人工智能

AI

60-70 年代

80年代 初期

90年代 中期

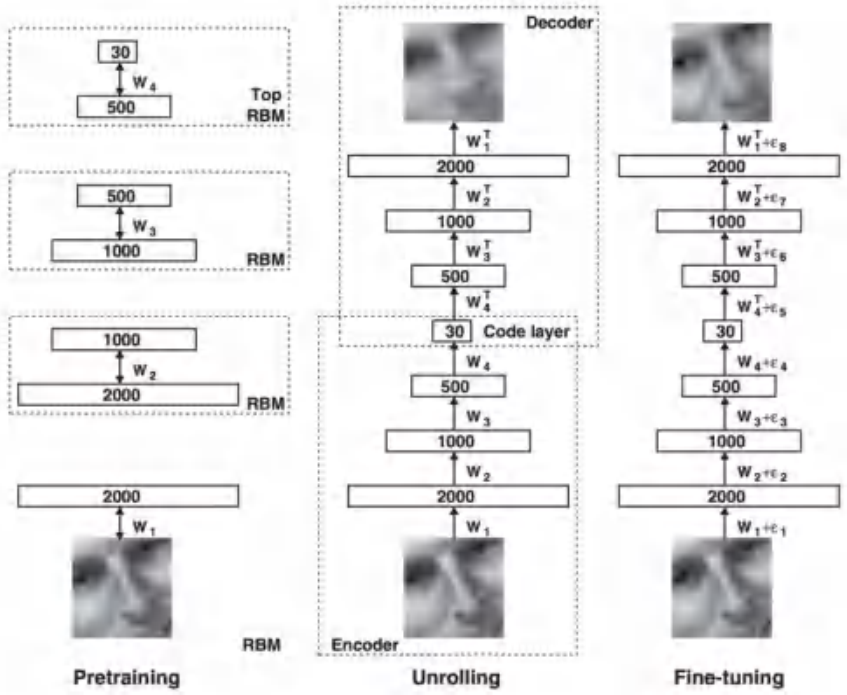


1950 1956 2006 2016

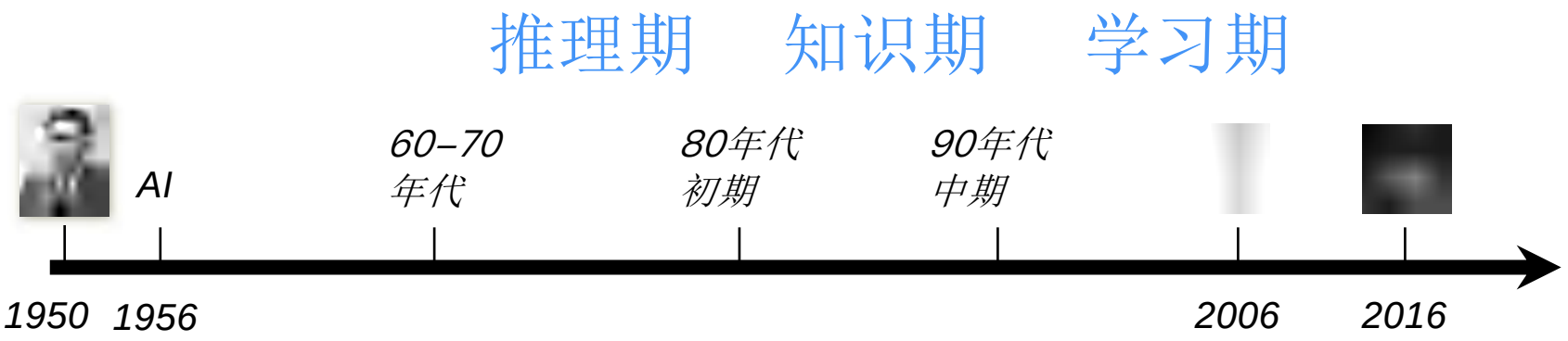
机器学习 → 深度学习

Geoff Hinton

深度学习虽缺乏严格的理论基础，但它显著降低了机器学习应用者的门槛，为机器学习技术走向工程实践带来了便利.



人工智能



2015年至今

《Nature》2015年2月统计学习先驱B. Schölkopf发文评论了基于学习的人工智能

《Nature》2015年5月发表7篇文章的专栏聚焦机器智能
深度学习、强化学习、概率机器学习、小型自主无人机

《Science》2015年7月发表人工智能专辑
机器学习、自然语言处理、计算理性、数据隐私

互联网巨头纷纷开源机器学习/深度学习系统
FBCUNN、TensorFlow、PaddlePaddle、Pytorch、SystemML、VELES

专用于机器学习等计算任务的通用GPU

历史中的人工智能

90年代初，第二次AI之冬

- AI硬件市场需求下跌
- 专家系统维护成本高昂
- 日本五代机失败
- DARPA大幅缩减AI项目资助

低估智能的复杂性

脱离现实问题

鲁棒性是硬伤

Machine Learning (

AlphaGo 并非“解决之道”

AlphaGo is not the solution to AI

Tags: AI,Machine Learning,Reinforcement – Jul 4 4:46 pm

Congratulations are in order for the folks at Google Deepmind who ha

However, some of the discussion around this seems like giddy overstatement. Wired says Machines have conquered the last games and Slashdot says We know now that we don't need any big new breakthroughs to get to true AI. The truth is nowhere close.

John Langford

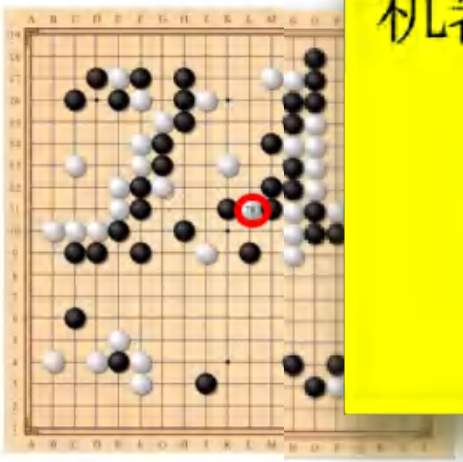
国际机器学习大会ICML'12的程序主席

人类犯错：水平从九段降到八段

机器犯错：水平从九段降到业余

离“超越人类棋手”还远

“鲁棒性”是关键 ！



3月13日李世石九段的“神之一手”

only came to that realisation on around move 87

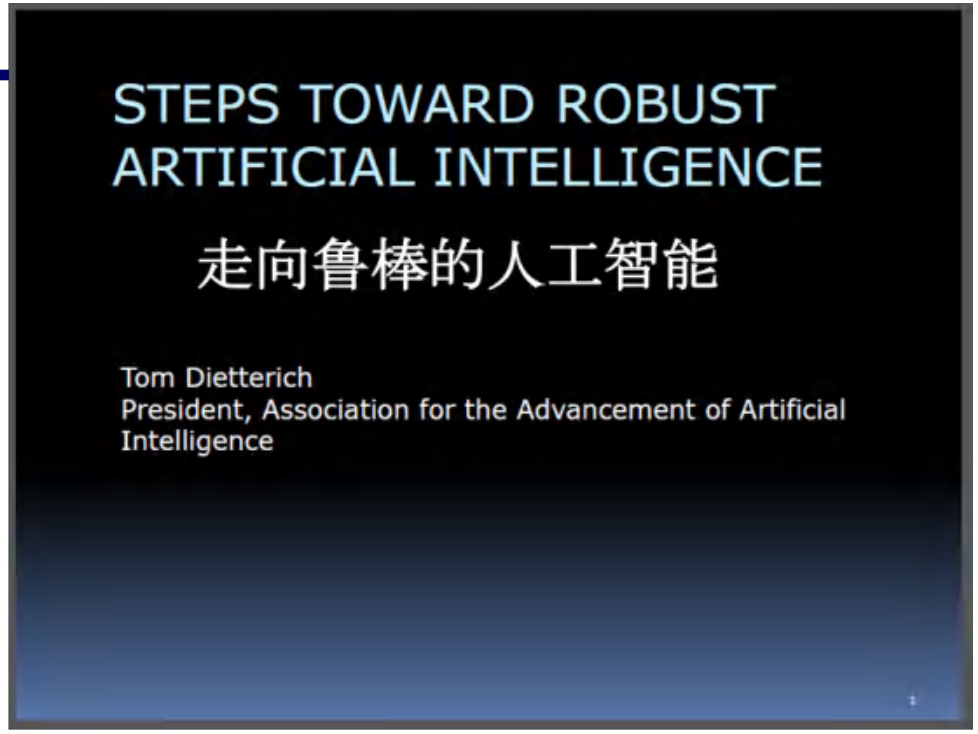
350 163

phaGo以为自做得很好，但第87手迷惑了。们有麻烦了

误出现在第79手犯了错误，但AlphaGo在第87手才发现

国际上对AI发展的探讨

AAAI “主席报告”
(“Presidential Address”)
2016.02.14



Tom Dietterich

AAAI/AAAS/ACM Fellow
AAAI 现任主席
国际机器学习学会创始主席 （2001-2008）

国际上对AI发展的探讨

T. Dietterich强调：随着人工智能技术的发展，越来越多地面临“高风险应用”

因此，必须要有“鲁棒的**AI**”

- 对人类用户错误鲁棒
- 对网络攻击鲁棒
- 对错误目标鲁棒
- 对不正确模型鲁棒
- 对未建模现象鲁棒

提纲

- 机器学习的定义
  - 关键词：经验、数据、性能
- 机器学习究竟是什么？能简述机器学习经典过程
- 机器学习能做什么？
  - 关键词：举1-2个例子说明
- 机器学习与其它学科的关系
- 前沿机器学习期刊和会议
- 机器学习的历史和可能的未来？
  - 推理期、知识期、学习期
  - 稳健机器学习对应开放环境