2019.07

跬步集

不积跬步，
无以至千里。
-荀子

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Column

博士之后（下）

亏得是张老师“帐下”得力战将数不胜数，组里人才精英荟萃，博后专辑竟需得两期才能小小的画上一个暂时的句号。当然，我也不禁暗爽，可算是偷得一个月小小的清闲，不必为了邀稿劳心劳力了。

所谓“Ph.D”、“博士学位”这一概念自然是发端于西方近现代的高等教育和文化体系，指的是指拥有人对其知识范畴的理论、内容及发展等都具有相当的认识，能独立进行研究，并在该范畴内对学术界有所建树。然而就在我写这篇专栏之时，一个问题映入我的脑海：虽是西方的“舶来品”，但“博士”这个词儿看起来倒不像“沙发”、“巧克力”之流没有任何语义只是傻乎乎的音译，会不会也有点什么古代的依照呢?

一查果然：“博士”最早是一种官名，始见于二千多年前的战国时代。司马迁在《史记·循吏列传》中有“公仪休者，鲁国博士也，以高等为鲁相。”秦朝时，博士官掌管全国古今史事以及书籍典章。到了唐朝，把对某一种职业有专门精通的人称之为“博士”，如“医学博士”、“算学博士”等。而宋朝，则

对服务性行业的服务员也称为“博士”。据《封氏闻见记》“饮茶”条记载：“命奴子取钱三十文，酬煎茶博士。”

这可太有趣了，不愧是我泱泱大国上下五千年的积淀，很少有词能完全独立于这体系之外需重新再造，博士这一词在古代的意思竟与现代西方体系不谋而合，有异曲同工之妙。

博士这一词在古代的意思竟与现代西方体系不谋而合，有异曲同工之妙。

当然我希望我们都能成为“唐朝博士”，对自己的领域精通有专攻，卓有建树；而不可像“秦朝博士”，只是坠于文献典籍之中，成一掉书袋，更不可像“宋朝博士”，沦为只会无脑刷刷试验数据的实验员、服务员了。

话题重拉回来，这期的博后专辑依旧是异彩纷呈，甚至填了一抹国际化“英特纳雄耐尔”的气息。首先是我们组新入职的两位博后，老面孔“大仙”莫扬之带来的关于低成本传感器的介绍，以及我的本科校友黄焕芳小姐姐的关于自然环境中滴滴涕（DDT）及其降解产物研究的论述。最后是我们组的国际友人MA HADI的广州生活经历，竟写成一篇论文的格式，煞是有趣。

伴随着广州高温暴雨循环播放而至的是甜美的假期，假期当然是个愉快的事情，可以让人休养生息，暂时从劳累枯燥的日常中脱身出来，也可以思考一些问题，看清一些东西。

博士之后？好像我们也该想想了。

就在此刻，我穿着白大褂坐在实验室的窗前，敲下这篇文字。而窗外的雨，还在淅淅沥沥地下。

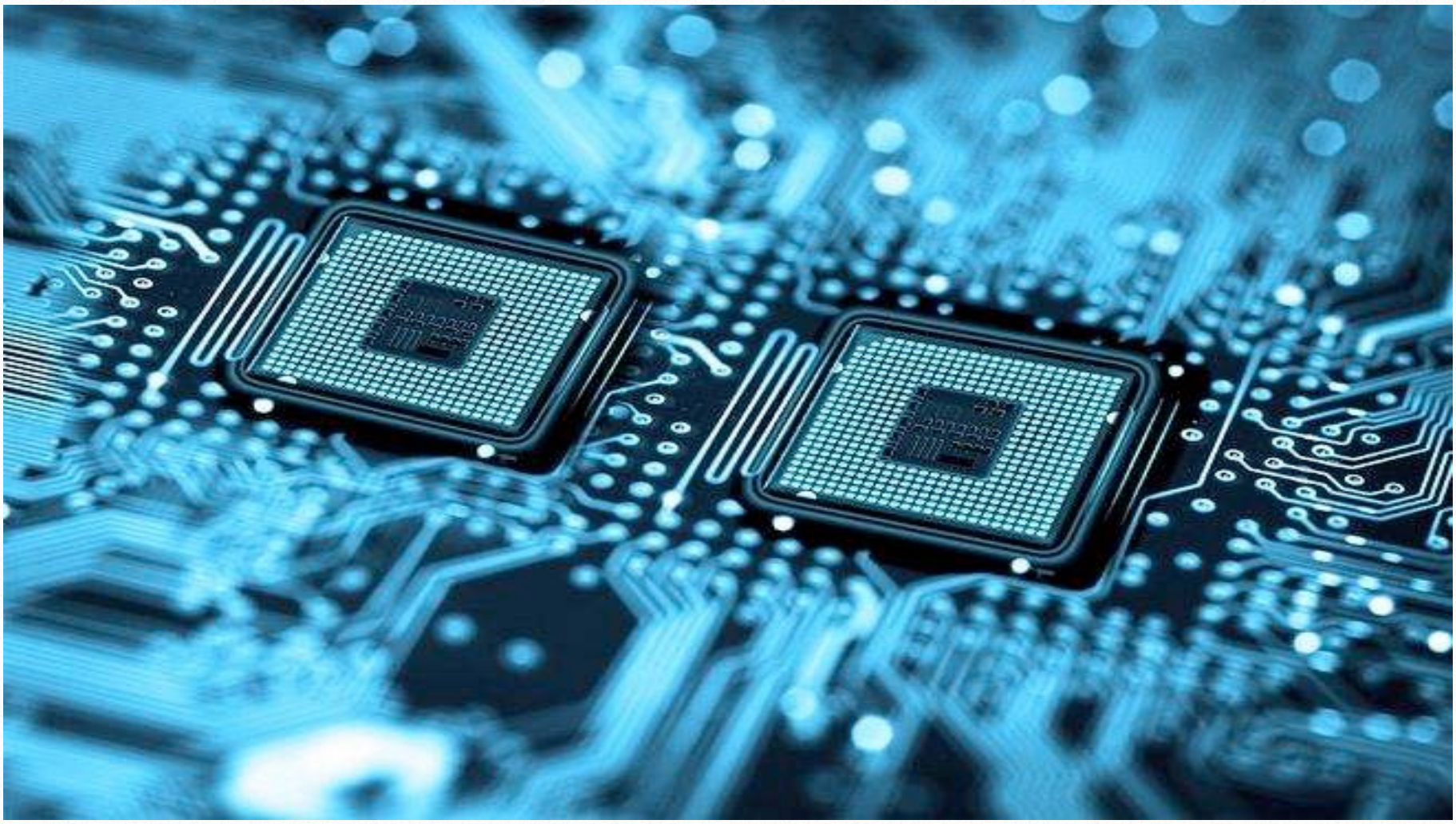
主编伯龙

2019.7.31

DISCUSSION

低成本传感器在空气质量监测中的应用与校正

莫扬之



清洁的空气是人类生存的必需品。然而，空气污染仍然是世界许多地区主要的环境问题，对社会经济发展产生不可忽视的影响(Hubbell et al., 2018a; Lewis et al., 2018)。随着全球城市化速度的不断加快，世界人口不断向城市区域集中，城市区域的空气质量水平也不可避免地下降。对大气污染物进行有效和准确的监测是保证群众的健康，提高公民环保意识和实施制定污染控制政策的前提。在过去的几十年来，多国政府机构已经在常规监测网点部署了昂贵和操作复杂的基准仪器，用于监测和研究空气污染。这其中包括，美国环境保护署（EPA），欧洲标准化委员会（CEN）和中国环境保护局（MEP）(Borrego et al., 2016; Spinelle et al., 2015; Wan et al., 2016)。但是，这类传统的基准仪器通常价格昂贵，而且需要使用人员拥有专业的技能和知识，所以这类仪器只能够部署在非常有限的监测网点。在城市环境中，由于大量的移动污染源的存在（例

如，机动车排放）(Fang and Bate, 2017; Lin et al., 2015a; Schneider et al., 2017)，使得城市大气污染物的时空分布更为之复杂。传统的观测网络在参考监测仪器数量较少的情况下，通常无法充分捕捉到城市环境中空气污染物小尺度的时空变化，从而识别出污染热点区域，这也为后续的治理带来了困难。因此，在城市区域亟需能够提供适当时空分辨率的空气质量监测技术，为公众评估暴露风险评估和污染控制政策制定提供依据。

在城市区域亟需能够提供适当时空分辨率的空气质量监测技术，为公众评估暴露风险评估和污染控制政策制定提供依据。

为了解决这个问题，有研究者尝把低成本传感器应用于监测大气污染物。低成本传感器作为一种新兴的大气监测技术，对专业技术人员和普通科学家都具有广泛的吸引力。它们拥有着多种多样的外型（如，箱式、手提式和手持式等）和可以同时集成多种样式的传感器。其中，这些传感器大多具有测定大气常规污染物的能力，例如O3,NO2和PM2.5等。相对于传统的基准仪器，低成本传感器具有价格低，容易使用，体积小和耗能低等优点（表1）。因此，低成本传感器适合用于建立城市区域密集的空气污染物监测网络，并可以用于（1）提高对城市内部空气污染时空变化规律的认识;(2)作为常规大气污染监测网络的补充;(3)增加对大气污染物暴露与人体健康的关系的了解;(4)应急响应管理、危险泄漏检测和污染源监测;(5)验证大气模型；并(6)提高公民对空气污染问题的认识和参与意识(Castell et al., 2017; Hubbell et al., 2018b; Maag et al., 2018; Morawska et al., 2018; Rai et al., 2017; Schneider et al., 2017)。低成本传感器也确实在常规大气污染物监测，源排放监测，移动监测，大气污染物源解析和人体暴露风险评估的研究中得到了一定的应用(Jiang et al., 2016; Spinelle et al., 2015; Sun et al., 2016)。然而，目前低成本传感器的应用还有许多限制，其中化学干扰和

表 1. 基准仪器和低成本传感器的比较

	基准仪器	低成本传感器
价格	$15,000 to $50,000	$100 to $2500
运行费用	昂贵	低廉
设定站点	只能够设定于固定站点	设定灵活
人员要求	人员需要专业的培训	不需要培训或少量的培训
数据质量	已知在不同的环境条件下，数据质量有保证	不同的传感器，不同的天气条件下，数据质量有所不同。
寿命	高于 10 年（为保证数据质量，需要定期进行校正）	未知或少于 1 年 （随着时间的增加，灵敏度可能下降）

环境要素是两个决定低成本传感器数据质量的关键因素(Castell et al., 2017; Maag et al., 2018; Rai et al., 2017)。研究表明，气流、温度、相对湿度、干扰气体和基线漂移等因素都会降低传感器灵敏度，影响数据质量。而且，对于同一批次同一类型的传感器，其灵敏度和相应时间都有可能不同(Capelli et al., 2014; Heimann et al., 2015; Leidinger et al., 2014; Mead et al., 2013; Piedrahita et al., 2014)。为了提高低成本传感器的数据质量，许多研究指出，这些传感器在使用之前应当进行全面的校正。在过去的十几年当中，如何校正低成本传感器一直是研究的热点。传感器的校准可以定义为一个数学函数，由自变量(传感器信号)和因变量(大气污染物浓度)构成。线性方程模型（包括多元线性方程）可能是其中最为简单和应用最为广范的校正模型(Spinelle et al., 2013; Zimmerman et al., 2018)。除了线性模型之外，最新的研究开始使用比线性模型更为复杂的统计数学模型，如偏最小二乘法，人工神经网络和高斯过程仿真等，对化学干扰和环境要素进行校正，以得到更好的研究数据(Kamionka et al., 2006; Lewis et al., 2016; WOLFRUM et al., 2006)。本文尝试对这些校正方法进行简单的介绍。

传感器类型

市场上用于空气污染物监测的传感器主要基于目标物污染物与传感器的化学反应，大致可分为两种：（1）金属氧化物半导体（metal-oxide-semiconductor， MOS）传感器；（2）电化学（Electrochemical， EC）传感器。

MOS传感器使用一种能够与大气污染物进行反应的金属氧化物作为涂层。当该涂层暴露于目标污染物中时，其电阻就会根据污染物的浓度而发生变化，也由此来测定目标污染物的浓度。

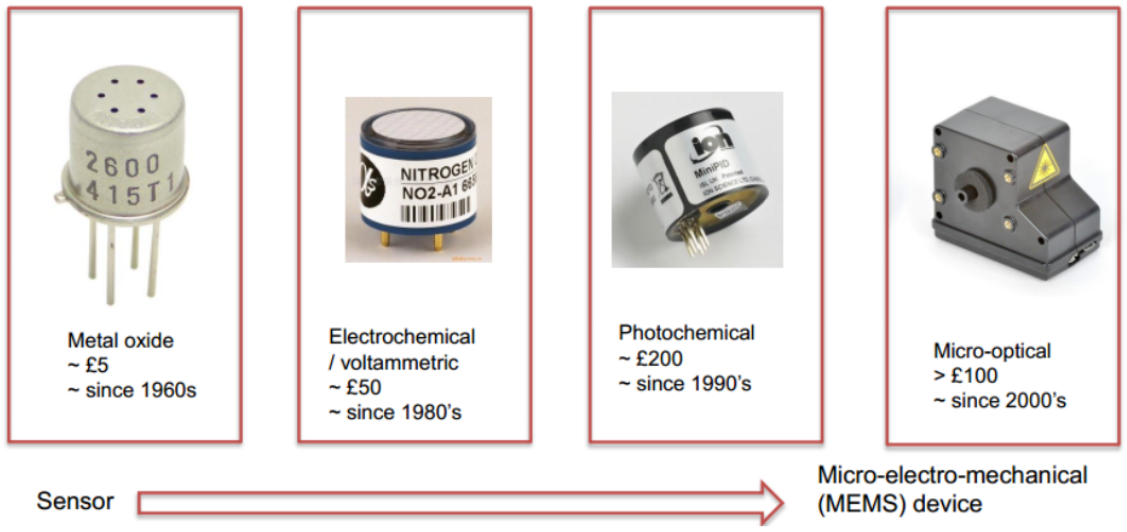


图 1. 各种不同的样式的低成本传感器

这种传感器具有体积小（几个平方毫米），重量轻，价格低（~$10），相应时间快，较低的检测限和功率需求（~100 mW）等优点(Aleixandre and Gerboles, 2012; Piedrahita et al., 2014)。然而，这类传感器对污染物的相应可能是非线性的，并且可能受到湿度，温度，压力和干扰气体的影响而灵敏度下降(Spinelle et al., 2016)。

EC传感器一般采用安培模式来进行空气污染物监测，即目标污染物气体与电解质之间的电化学反应所产生的电流依赖于气体浓度。EC传感器通常由工作电极，辅助电极和参比电极构成。目标污染物通常在工作电极发生氧化还原反应，期间所产生的电荷通过辅助电极上的反应得以平衡。电极对之间的电流与气体浓度之间可以是线性关系，也可以是对数关系(Aleixandre and Gerboles, 2012)。参比电极则主要用于确保工作电极保持在正常的工作电位。EC传感器相对于MOS传感器来说，其拥有更低的检测限，功率需求更低（~100 μW），不易受到环境因素和干扰气体的影响，但是EC传感器的体积普遍较大（几十平方毫米），并且价格更贵（~$100）(Aleixandre and Gerboles, 2012; Piedrahita et al., 2014)。

除了上述基于化学反应的传感器，还有其他的非化学类型的传感器可用于大气污染物监测，例如，非色散红外辐射吸收传感器（Non-dispersive infrared radiation absorption，NDIR）和光解电离传感器（Photo ionization detection，PID）。 NDIR传感器当中具有一束红外光，通过测定与目标气体相匹配波长处的红外吸收强度，即可得到目标气体的浓度，这种传

感器大多用于测定CO2(Snyder et al.，2013)。PID传感器的原理则是气体分子吸收的紫外线所产生的电流与目标气体浓度成比例，PID常常用于测定VOCs的浓度(Lewis et al., 2016)。

传感器的误差来源

低成本传感器的数据准确性，决定着其应用前景。一般的研究认为环境要素和非目标污染物的交叉干扰是低成本传感器主要误差来源。

A.环境因素

研究已经证实特定的一些环境因素，特别是温度和相对湿度，能够在很大程度上影响传感器的响应。例如，空气湿度能够影响MOS传感器的导电性，并且当水蒸气附着在传感器涂层上的时候，能够与涂层上的物质反应，从而改变传感器对目标气体的响应(Peterson et al., 2017)。而且，环境因素对传感器的干扰作用不是固定值，而是在相对较宽范围内变动，这也给相应的校正工作带来了难度。

B.交叉干扰

典型的MOS和EC传感器的选择性都较差。传感器的反应涂层除了和目标气体反应之外，还会与其他非目标气体反应。这种交叉干扰是不可避免的，特别是在成分复杂的室外大气中，而这些交叉干扰给低成本气体传感器的应用带来了很大的挑战。例如，O3通常是NO2 EC传感器的主要交叉干扰物，干扰的程度能够高达100%，这在一定程度上使得传感器测得的数据是O3+NO2(Lin et al., 2015b; Mead et al., 2013; Popoola et al., 2016)。虽然有时候干扰气体对传感器的干扰程度较低，但在环境空气中测量时，特别是在被测物浓度较低和干扰气体浓度较高时，交叉干扰可能产生明显的信号干扰(Lewis et al., 2016)。

校正方法

目前，对低成本传感器的校准主要有两种方法:实验室校准和场地协同校准。这两种方法都有各自的优点和缺点。

A.实验室校正

实验室校准指的是在实验室中对传感器在受控的条件范围内进行校准(Castell et al., 2017; Mead et al., 2013; Piedrahita et al., 2014)。然而，在实际的大气中存在着各种化学反应和其他难以意料的影响传感器性能的因素，这些都是在实验室中难以模拟的。此外，这种方法需要高精密度的分析仪器和混合标准气体，实验要求也比较高。但总体来说，实验室校正对于确定低成本传感器在特定、受控条件下的运行情况是非常有用的，这有助于我们了解其基本工作原理。

B.场地协同校正

为了克服实验室校正中存在的一些限制，许多研究发现场地协同校正是更为之有效的一个方法。这种方法主要指把传感器放置在参考仪器附近一段时间（主要在各个环境监测站），这就能让低成本传感器输出数据能够与参考仪器输出数据得到直接的比较。因为这种校准方式是在实际大气条件下进行的，所以更具有现实意义。然而，要在短时间内测定传感器对所有范围内的目标气体、干扰气体和环境参数的响应是很困难的，这也使得现场地协同校正工作相当费时。

校正模型

A.线性回归模型

线性回归模型包括一元回归模型（Y=a*X+b）和多元线性回归模型(Y= f (X1，X2，X3…))，这两种方法最广泛应用于低成本传感器的校正。传感器的信号通常取决于多种因素（如，温度和湿度），所以简单的一元回归模型并不能表达这些因素之间的潜在关系，这就使得这个模型在实际应用中的准确度不高(Lin et al., 2018; Maag et al., 2018)。相反，多元线性回归模型能够将多种相关的因素作为输入来限制传感器的输出值，让数据更加准确。然而，需要指出的是，有时候多元线性回归模型对颗粒物（如，PM2.5）校正的表现并不太好，这可能是有

时候一些影响传感器数据的因素与传感器之间的关系并不是线性的(Fang and Bate, 2017; Maag et al., 2016)。

B.聚类模型

目前主要存在两种聚类模型，基于数据的聚类和基于传感器的聚类。基于传感器的聚类：Smith et al. (2017) 发现干扰因素对单个传感器的干扰作用不一定是单一的固定值，但可以限制在一定的范围内，这意味着这些干扰因素不能假定为常数。使用聚类传感器的中值能够排除多个传感器中的离群值，而且聚类传感器中值与基准仪器的相关性更好。基于数据的聚类：数据的聚类可以采用K临近算法（k-nearest-neighbor，KNN）实现(Hagan et al., 2018)。一般来说，与线性回归方法相比，KNN算法给出了更精确的结果，并成功地描述了传感器信号对温度的非线性响应。

C.人工神经网络模型

人工神经网络（Artificialneural network，ANN）常常用于数值预测(Zhang et al., 1998)。Cheng et al. (2014) 提出了一种基于ANN算法的低成本传感器校正方法。在这方法选择了选用了应用最广泛的反向传播(back-propagation，BP)神经网络，并且能够很好的拟合任何函数。Spinelle et al. (2015, 2017) 评估了一元线性模型，多元线性模型和ANN模型在多种传感器校正上的表现。他们发现，相对于一元线性和多元线性模型，ANN模型的表现更好，能够将相关系数（R2）从低于0.3提高至不低于0.85。但是，ANN模型需要使用已知数据集进行训练，对未知数据的预测能力较差。为了解决这个问题，Dong et al. (2015) 提出了一个结合了ANN和支持向量机（support vector machines，SVMs）的方法，但这个模型可能在某些特定的情况下有丢失精确度的可能。

人工智能与机械学习

以上说的这些模型算法，看起来可能有点云里雾里的，其实这些都是从统计学衍生过来的基本算法。可以说都是一些处理大数据的基本算法，可以归入现在非常火的机器学习

（Marching Learning）领域，从广义上来说，机器学习是一种能够赋予机器学习的能力以此让它完成直接编程无法完成的功能的方法。但从实践的意义上来说，机器学习是一种通过利用数据，训练出模型，然后使用模型预测的一种方法。机器学习可以借用网上很火的一幅图来表达 （图2）：

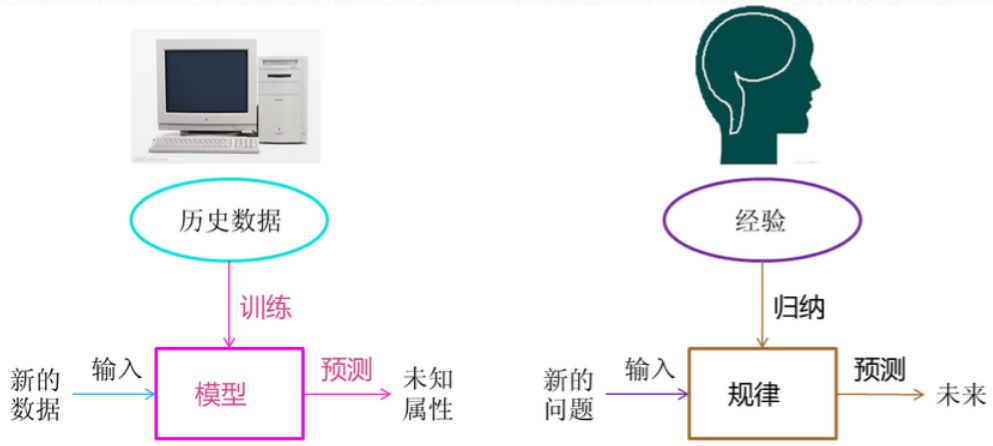


图 2. 机器学习与人类思考的类比

人类在成长、生活过程中积累了很多的历史与经验。人类定期地对这些经验进行“归纳”，获得了生活的“规律”。当人类遇到未知的问题或者需要对未来进行“推测”的时候，人类使用这些“规律”，对未知问题与未来进行“推测”，从而指导自己的生活和工作。

机器学习中的“训练”与“预测”过程可以对应到人类的“归纳”和“推测”过程。通过这样的对应，我们可以发现，机器学习的思想并不复杂，仅仅是对人类在生活中学习成长的一个模拟。由于机器学习不是基于编程形成的结果，因此它的处理过程不是因果的逻辑，而是通过归纳思想得出的相关性结论。

下面我会简单介绍一下，上面所写到几个模型的基本知识：

A.回归算法

这个是最简单的模型，大家平时建标准曲线用的就是回归算法的思想。这跟标准曲线一般使用“最小二乘法”来求解。“最小二乘法”的思想是假设我们拟合出的直线代表数据的真实值，而观测到的数据代表拥有误差的值。为了尽可能减小误差的影响，需要求解一条直线使所有误差的平方和最小。

B.神经网络

神经网络(也称之为人工神经网络，ANN)算法源于对大脑工作机理的研究。早期生物界学者们使用神经网络来模拟大脑。机器学习的学者们使用神经网络进行机器学习的实验，发现在视觉与语音的识别上效果都相当好。简单来说，神经网络就是分解与整合。比方说，一个三角形，分解为三条折线进入视觉处理的下一层中。三个神经元分别处理一个折线。每个折线再继续被分解为两条直线，每条直线再被分解为黑白两个面。于是，一个复杂的图像变成了大量的细节进入神经元，神经元处理以后再进行整合，最后得出了看到的是三角形的结论。这就是大脑视觉识别的机理，也是神经网络工作的机理。在神经网络中，每个处理单元事实上就是一个逻辑回归模型，逻辑回归模型接收上层的输入，把模型的预测结果作为输出传输到下一个层次。通过这样的过程，神经网络可以完成非常复杂的非线性分类。

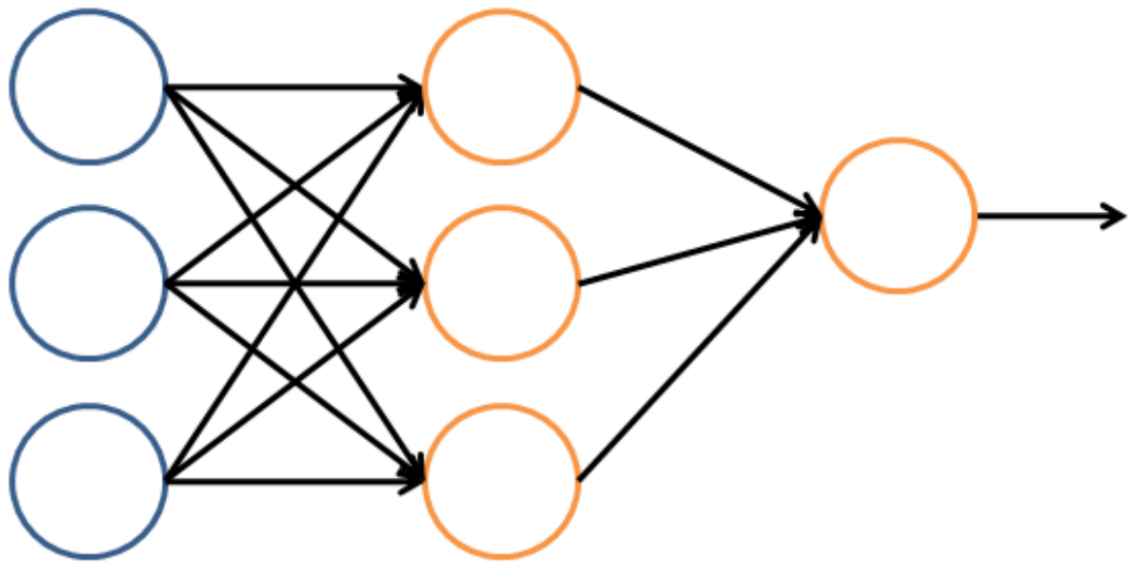


图 3. 神经网络的逻辑架构

C.聚类算法

前面的算法中的一个显著特征就是我的训练数据中包含了标签，训练出的模型可以对其他未知数据预测标签。在聚类算法中，训练数据都是不含标签的，而算法的目的则是通过训练，推测出这些数据的标签。这类算法有一个统称，即无监督算法(前面有标签的数据的算法则是有监督算法)。无监督算法中最典型的代表就是聚类算法。

某一个数据包含两个特征。我希望通过聚类算法，为了给他们中不同的种类打上标签，则可以根据距离的远近将数据划分为多个族群。 聚类算法中最典型的代表就是K-Means算法和Hierarchical算法（图4）。

套用华为老总任正非的一句话“无论你学得多么快，不如机器快；无论你学得多么久，你的生命总是有限的。未来人工智能对人类社会具有极大的继承性，科学家的思维和思维方式可能被继承下来。”为了不被时代淘汰得太快，本人只是对非常有限的一些内容进行涉猎，对很多相关知识点还不是太过了解。但起码在将来别人问我机器学习算法有哪几种的时候我起码说得出有回归算法，神经网络和聚类算法之类。起码不会像别人问我有什么著名的包包牌子，我只能答得上：路易斯维登和LV。

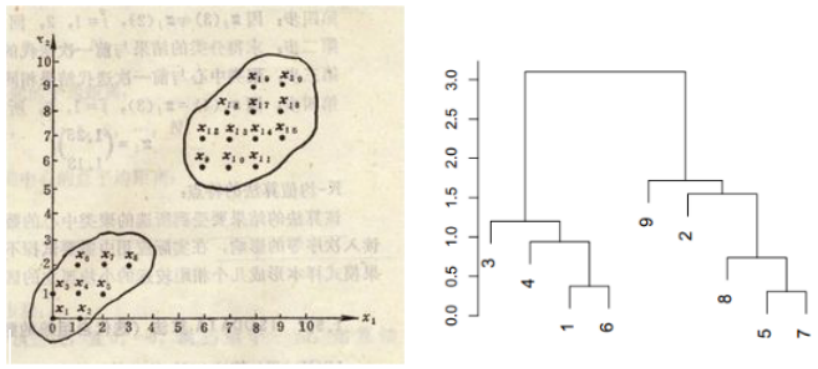


图 4. K-Means 算法（左）和 Hierarchical 算法（右）典型例子

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Discussion

关于自然环境中滴滴涕（DDT）及其降解产物研究的一点呈现

黄焕芳

有机氯农药（organochlorine pesticides，OCPs）作为持久性有机污染物（Persistent Organic Pollutants，POPs）的重要组成，具有高毒性、持久性、半挥发性和亲脂憎水性，是对人类健康和环境具有严重危害的有机化学污染物质。而滴滴涕（DDT）是OCPs中重要的一类，具有POPs的典型性质。

自然环境（土壤和大气中）DDT及其降解产物研究是我博士论文的一大部分，来自于我的博士导师祁士华教授的面上项目《高原长距离迁移过程中有机氯农药降解中间化合物研究及其环境意义》。基金中关于有机氯农药降解研究的目标之一是利用其降解化合物进行环境要素和迁移示踪的探索。简而言之，是寻找不同环境下OCPs的特征单个产物或者产物组合（或者比值）作为该环境

（环境要素或者环境行为）的特征指示。研究区为四川盆地-黄河源头剖面（～1000 km）。以目前已有的研究举个简单的例子，DDE是DDT的好氧降解产物，而DDD是厌氧降解产物，那么（DDE+DDD）/DDT可用来判断环境中是否存在DDT的新近输入，而DDE/DDD的高低比值可分别反映降解环境的氧化还原条件。当然基金的目标更深入、更广。我们希望能够通过尽可能地检测到环境介质中更多的更高级的降解中间产物，来揭示不同自然环境条件下OCPs降解过程和降解动力学，寻找OCPs长距离传输的降解中间化合物新型示踪指标以及OCPs降解中间化合物标志物对自然环境条件的响应。目前国内外关于OCPs降解的研究主要集中在室内实验上，自然环境中OCPs降解的研究非常少，而寻找自然环境下的降解新型标志化合物，和探索OCPs降解中间化合物对自然环境要素指示是OCPs研究的创新型思路和探索。

目前国内外关于OCPs降解的研究主要集中在室内实验上，自然环境中OCPs降解的研究非常少。

我的博士研究方向集中在OCPs的长距离迁移和DDT降解研究（降解产物鉴定、降解途径揭示等）。之所以会选择DDT作为我的研究对象，是因为目前DDT的室内降解研究（可能的降解产物、降解类型、降解原理等）最为透彻。大量的室内试验结果可为野外研究提供可靠的基础数据和依据。研究结果呈现了四川盆地-黄河源头剖面上OCPs的双向迁移，揭示了剖面不同区域土壤和大气中降解产物的时空分布状况、推测了可能的降解途径，并定量诊断了降解产物的来源。我也曾尝试在自然环境样品中寻找特征的产物和产物组合，但即使我们尽可能地优化了仪器条件，由于背景区（青藏高原）OCPs及其产物浓度极低，很多高级产物处于未检出状态，再加上研究区的开阔性和自然环境的复杂性，因此，非常惭愧，未能在我的博士论文中

体现祁老师的这一思想。为了解决这一难题，我们在研究剖面不同海拔点设置了实验。往土壤中人为添加了高浓度POPs（OCPs和PAHs），在当地特殊环境条件下，进行长期（>1年）的降解监测。这一部分的研究正在进行。关于确定自然环境下降解路径的另一个难点是寻找更直接的更可信的（robust）证据。我们的思考方向是是否可利用同位素或者手性特征手段。若大家对我们的研究有兴趣，非常欢迎大家莅临指导，参与讨论，提出宝贵建议和意见。

以下是对DDT降解产物的简单介绍。

DDT的降解类型可分为两大类：生物降解和非生物降解。生物降解细分为细菌降解、真菌降解、动物降解和植物降解。在生物降解中，微生物降解是最广泛的，动物和植物降解也与微生物降解有密切联系(Barker et al., 1965; Mendel and Walton, 1966)。非生物降解包括光降解和化学氧化降解。DDT的降解机理主要包括还原脱氯作用、去氯化氢作用、氧化作用、水合作用、脱羧基作用等，每种类型的降解均是几种机理的综合作用。

p,p’-DDT的降解产物主要包括初级产物p,p’-DDE和p,p’-DDD，和高级产物p,p’-DDMS、p,p’-DDMU、p,p’-DDNU、p,p’-DDOH、p,p’-DDNS、p,p’-DDA、p,p’-DDM、p,p’-DBP等（表1）。值得注意的是，在环境中残留的dicofol除了来源于商业使用之外，还有可能来源于工业滴滴涕的降解，而后者却处于被忽略状态(Huang et al., 2018)。

大部分p,p’-DDT的降解产物均具有与p,p’-DDT类似的半挥发性、持久性和亲脂憎水性（表1），从而拥有与OCPs相似的环境行为，比如备受关注的生物累积效应、大气长距离传输和干湿沉降等。DDT及其相关的降解产物均可以被植物摄取(Lunney et al., 2004)，进而通过食物链传递给捕食者，储存在高级生物体的脂肪组织中(Aislabie et al., 1997; Naso et al., 2003)。一些高级的降解产物，还可能具有较高的水溶性，显示出比母体和初级降解产物更高的生物利用度(Semple et al., 2004)。比如，p,p’-DDA和p,p’-DBP在25°C下的水溶解度分别为5.85和3.80 mg/L（表1），比p,p’-DDT和p,p’-DDE的溶解度（分别为0.007 mg/L和0.027 mg/L）高至2个数量级。p,p’-DDOH的溶解度更是高达24.770 mg/L（表1）。前人研究显示，德国柏林某饮用水厂的地下水取水井中，单是p,p’-DDA的浓度，便已超过欧盟饮用

水对农药的限值（0.1 ug/L）(Heberer and Dünnbier, 1999)，值得引起注意。Wetterauer 等(2012)对p,p’-DDT的4种降解产物p,p’-DDA、p,p’-DDMU、p,p’-DDMS和p,p’-DDCN的细胞毒性、类二恶英活性和类雌激素活性做了评估。结果显示，所有降解产物对RTG-2细胞均具有细胞毒性，但对RTL-W1细胞无类二恶英活性。雌激素活性的大小排序为p,p’-DDMS > p,p’-DDMU > p,p’-DDCN，比母体p,p’-DDT略低。相反，p,p’-DDA显示出具有中等水平的抗雌激素效果。尽管尚无研究全面准确地评估每个p,p’-DDT的降解产物对人体健康的具体影响，但不能排除其影响人体健康的可能性，包括慢性作用(Aislabie et al., 1997)、细胞毒性和类雌激素活性(Wetterauer et al., 2012)等。到2015年为止，p,p’-DDT的降解产物，只有p,p’-DDE和p,p’-DDD被列入了《关于持久性有机污染物的斯德哥尔摩公约》受控名单(Xu et al., 2013)中（p,p’dicofol是以农药杀螨剂的身份被列入候选控制物质名录中，而非p,p’-DDT降解产物身份）。

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LIFE

My experience in Guangzhou, China

MA HA DI

I have been living in Guangzhou since 2017 when I came here as a postdoctoral researcher in Guangzhou Institute of Geochemistry (Chinese Academy of Science) located in Tianhe district. I would say that living in Guangzhou is like living in any big Asian city but there are some aspects that make me prefer Guangzhou over other cities in China and other Asian cities:

• Guangzhou is relatively relax compared to Shanghai where people always seem in a rush;

• The expat scene is more diverse because of smaller groups and people being 'forced' to mix friends, e.g. more international cities have large communities of 'only' Dutch, French, and American,…, etc.

• The metro is really good in Guangzhou, also very crowded during rush hours on

particular lines so that is not always convenient;

• Guangzhou is very conveniently located, 2 hours by train to HK, close to Zhuhai which is nice for a weekend and many South East Asian countries are within a couple of hours flight;

• Guangdong is what some call the factory of the world, if you are in the trading business Guangzhou is perfect;

• As others have noted, Guangzhou is very safe. I have never felt unsafe regardless of the time, location or 'state' is was in.

Moreover, there are many things here that everyone can enjoy in GZ where the green space and flowers are the main features along with tall and luxury buildings.

Guangzhou – My experience here

Before coming to GZ, I have studied almost 3 years for my PhD in Zhejiang University located in Hangzhou (Zhejiang province). So, I had an idea about life style and traditions in China. However, my experience in GZ has been quite different and more pleasant since here is the third largest city in China with much more friendly people. Moreover, there are many things here that everyone can enjoy in GZ where the green space and flowers are the main features along with tall and luxury buildings.

The first thing I have seen in GZ after coming from the airport was enormous skyscrapers and an extremely green city! The bridges are covered in flower pots, many alleys, parks with ponds, bushes and greenery, and a lot of people exercising in the parks. There are many local tourists in Guangzhou, visiting the Chimelong safari, circus, water and entertainment parks. Most of the foreigners come here for business. Another interesting point is that there are many people who are working on

cleaning and fixing the face of the city and almost everywhere you can see the fresh plants and flower.

Another interesting point is that I am able to access almost everywhere in GZ using just bus and subway. There are several metro lines with numerous numbers of station through the city which makes me so comfortable since I do not know Chinese. Compare to Hangzhou, Guangzhou has much wider distribution of buses and to be honest, I love bus line 191 which can cover 60% of the places I usually go. That is interesting, isn't it?

If I want to talk about the daily life in Guangzhou, I must mention that living here is similar to living in all southern cities in other countries since the people here are so nice and relax with no rush at all. There is an expression in Chinese "Man Man Lai" literally means gradually things go forward. I heard this in Hangzhou, but to be honest, I see it here. Although they are working hard and most of their time they are inside the office working on the tasks they have, there is no rush in negative meaning. I have seen some cities in China and if I want to compare, I would say that people in GZ are among the most efficient people across China as they think a lot about what they want to do, make a plan and then act with no stress. I really liked it and I have been trying to copy this method in my personal life. Sometimes, my wife tells me that you are Chinese now since I am using this slang a lot and try to use it in a good way.

Well, about the people of China I can talk two hours nonstop, but the main points about GZ citizens could be nice, helpful and so hospital. They are ready to give you a hand when you need and believe me or not, most of the time they give you more than you need. If you ask them about the address, if the address is in their direction they come with you to show or if they have a care, they will give you a ride. This is one of the thing that makes me so thankful of Chinese citizens living in GZ.

Places worth to see even if you are here for a week

Canton Tower

Canton tower with 600 m tall as the tallest towers in the world in my opinion is something of "build it and they will come" type. The tower lights up nicely during the night and you

can take a bubble tram at the top, but there isn't much of practical purpose for this structure. The tower is located near Zhujiang New Town and it could be seen almost from everywhere in day if there is no fog. This tower could be considered as one of the symbols of GZ showing the prosperity of the city and the people living inside. In addition, since there is a river named Pearl river nearby with several cruise tour on it and an street next to the river, which is full of bars and beers and other things, this area could be a great choice to see how things work in GZ.

Another thing about GZ that I like is the markets here. In my opinion here I could fine everything in so many different colors and designs which makes it suitable for me when I need to walk around and see different products in different colors to get rid of the scientific ideas I am dealing with it every moment. And interestingly, I could find everything from cheap low quality items to high and expensive brands in different locations inside GZ. That is so nice to see you have lots of options when you decide to buy things and all the time the service they provide, is better than the places I have been before. However, according to "Man Man Lai" rules, things are a little bit slower than the north where people are in rush all the time.

The food here is also significantly better than north as I was able to find almost every type of the food I wanted, from Chinese to Iranian and Western. As these people are using more spice than other cities in China, the food is tastier and colorful which makes me more comfortable. However, I should not forget to say that all of my pleasant time here comes from the great working place (GIG) which I am working in. People here in this institute have been so so helpful and friendly and every time I was concerning about something I saw the hands coming to help me from here and there. GIG is to be honest, the greatest working place I have been so far with lots of green space, nice retired employees with nice smile on their faces and great working staff and scientists. To be honest, as I have seen, people here behave like a family and they embrace new comers as a new family members immediately. If you add great instruments and nice food provided by institute restaurant, you can find out how comfortable I am here. Although our institute is a little bit out of the crowded areas in GZ due to the place of institute which is near the highways and railways, I really do not need to go out for refreshment as the environment here is like my home.

The new city has such large shopping malls as previously mentioned Grandview Mall, next to it is the Tee Mall and Tai Koo Hui, and not far from the opera is the Friendship Store. What surprised me the most in the Grandview Mall was the contrasts of it all – 7 stories high place with fanciest brands, cafes, even an aquarium, but once you enter the restroom, there is a hole in the ground, so called “oriental bathroom”. No paper, no soap, not even the hose as you would usually expect it in Turkey. When I visit exotic places, I always enjoy visiting the supermarkets. Guangzhou has an up-scale supermarket called Taste. You can buy Chinese hands cream with snake extract, chopsticks, rice bowls with cats and numerous fruit (including the stinkiest fruit in the world – durian). I also enjoyed just watching what is inside the freezers. Funny thing though, couldn’t find a single Chinese made brand of chocolate! And, as in many places in Guangzhou, it was tricky to pay with a European credit card, only one cashier knew how to do it. Most of the ATM’s work just fine, but sometimes you have to look for one really hard, easiest way to find one is to find a large hotel.

Guangzhou has also a different side of shopping – for wholesale purposes. Hundreds of thousands of useless plastic toys, home design items and trinkets. Star Wars figurines, Hello Kitty purses, key chains and so, so many pillows, shelves, garden gnomes and lamps. One of examples of such shopping malls is the Onelink Plaza that has about 7-8 regular floors and at least as many showroom halls floors. Such stores are nothing unusual around Sacred Heart cathedral. You have to bargain to get a better price, but usually you would need to buy quite a few items then. Many of the clerks told me that they only start giving discounts if you buy at least a hundred items. But sometimes you can get a better price if you buy even just two. Such places sell toys where on the package every sentence has at least three mistakes in the English language and probably most of them would be banned in the European Union. When you enter the store, don’t be surprised that the clerk won’t pay any attention to you, will be eating or even sleeping.

Eating in Guangzhou

Visiting Guangzhou did not become a test for my tastes, as not only I could eat the food here, I quite enjoyed it! Chinese told us that we are extremely lucky to start our visit with Guangzhou, as Cantonese food is the tastiest in all China! But, there were the weird bits

too, such as poultry would be brought together with the head of the bird. Everywhere we went, it was the Swinging Sally principle – one large table in the middle of the table that you could move to bring the desired dish closer to you. It was also interesting that firstly all the meat dishes were served and only in the very end we got rice, noodles and bread. We didn't see almost any dessert, it usually was just some fresh fruit or egg tart (from the Portuguese times). You could drink very light beer or traditional puerh tea, which is fermented for many years. Supposedly very healthy but tastes like water from the bog, autumn leaves and old sneakers.

One of the most interesting locations for a meal is the Hongxing seafood restaurant, which is next to the Tainzi dock. You can see and eat everything that lives in the water, starting from sea cucumber to five types of prawns, crocodiles and enormous crabs. For regular meals we chose a restaurant not far from the hotel. The way we made the selection was that we looked which of the places had the most locals in it. Of course, all of the menus where in Chinese! But the waiter took out her smartphone with a translation app, we could type in what kind of dish did we want and she would show which is the one on the menu. For longer visits to China and especially outside the large cities I would recommend a dictionary that works offline. Although there are numerous free wifi spots in Guangzhou, most of those require local phone number to be activated. Sometimes locals would activate the access codes with their phones and help us out.

There is also plenty of opportunity to eat in one of the skyscrapers, such as Canton tower, IFC or any of other hotels that usually have a restaurant on the top floor. I would suggest booking in advance, as these locations tend to be very popular. Interestingly, none of the local waiters accepted tips, even run to give those back. Even one of the shopping malls assistants rushed to find me when I had left some small money not waiting to get it back. People where very polite in Guangzhou and always tried to help us, and only school girls wanted pictures with us.

In Conclusion

I have been to many cities and countries in the past few years, most of those I would gladly visit but wouldn't want to live there. Guangzhou is one of the few cities where I

could picture myself living in! People are polite, try to help and it is a very safe place. A proof of that is the postal station in the middle of the city, where they sorted packages on the street and none of the passers by expressed any interest in the packages. No obtrusive scratchers with long nails and no dirty streets (even saw them being washed with soap!).

Guangzhou does have a few cons though. Smoking is allowed almost everywhere, which means that you will have to eat your meal covered in cigarette smoke. No interest to the post packages from passers by, but probably also no interest to deliver the post – none of my postcards reached their destinations, and – pollution. Even when the days where supposed to be sunny, we never saw the sun, the city was covered in smoke-like clouds. The only sunny morning was after it had heavily rained on the previous day.