

5.3 用户的隐私保护和安全性问题

在大数据时代,无论是通过告知用户取得许可,还是把关键信息模糊化或匿名化,就算消灭了个人敏感信息,也不能消灭数据中存在的社会关联关系,这三大隐私保护策略都不能真正地保护用户的隐私^[74].尽管用户对个人隐私泄露的担心阻碍了其分享详细轨迹的热情,但是随着数据量和数据种类的增多,综合分析数据会泄露个人隐私.对各类数据进行综合分析是推荐过程必经流程,例如对轨迹数据进行聚类、时空分析等操作就有可能获取用户的家庭位置、工作地点、兴趣点、热门路径和轨迹出现规律等等隐含信息.另外,用户分享的轨迹数据还蕴含着用户的当前位置和用户的社会属性等等.显然,用户位置和社会属性是用户的核心信息,属于用户隐私^[60,61].虽然在研究中时刻强调用户隐私保护和安全问题,但在实际应用中却又迫切需要用户的这些信息^[7].除此之外,当前智能移动设备非常普及,用户的移动设备在无线通信时会泄露位置信息,例如接入基站的位置、WIFI 接入点位置、用户报告(注册移动应用和服务填写的信息)等,综合分析就可以得出用户精确的位置和姓名、职业、电话等社会属性.显然,用户的隐私保护也是当前基于轨迹数据的精确移动推荐研究中的难点和热点,如何在保护用户隐私的前提下提供个性化的精准推荐,是一个重要的研究方向.

5.4 基于用户轨迹数据集的移动推荐评价问题

在推荐系统领域,评价指标有推荐效果和推荐效率两种指标,常见的推荐效果评价指标是 Precision、Recall 等,相应的推荐效率指标主要是指推荐算法的时间复杂度.这些指标继承于基于互联网信息检索领域^[71],并且目前基于用户轨迹数据的移动推荐评价基本上也是这些指标.

然而,基于轨迹数据的移动推荐系统使用的是广义轨迹数据,轨迹数据特有的时空性、序列性等特性对推荐过程和推荐效果产生了很大的影响,但是并没有合适的指标对这些影响进行量化和对比.例如,POIs 序列推荐,序列反映着结果的重要性或紧迫性,但是当前的准确率评价指标却没有考虑序列因素对推荐结果的影响.综上所述可以看出:除了继承移动推荐的部分评价指标外,还需要根据基于轨迹数据的移动推荐制定更加合适的专用评价指标.

5.5 基于用户轨迹数据推荐的推荐性能提升

近年来,基于用户轨迹数据的移动推荐研究取得了较大的进展,随着研究的向前推进,人们越来越注重推荐效果和推荐效率等推荐性能的提升.显然,持续产生的新数据和用户对推荐响应时间和准确性的需求是最主要的推动力.具体来说,可以分为两个问题:(1) 实时产生的新数据,如何通过合适的途径快速引入推荐模型,并且提取用户偏好的变化,高效计算出改变后的用户偏好;(2) 如何根据用户的历史数据,快速生成推荐结果.在这种情况下,算法的效率、精准性成为研究的重点.为了实现算法的高效性,目前研究显示主要有 3 类方式.

- (1) 建立离线/在线框架.将复杂的计算复杂度剥离到离线模块;而推荐生成过程使用轻量级的算法,放置在线模块.这就要求设计模型时,高计算量的部分和轻微计算量的部分有明显的划分,并且在划分之间的耦合度要低^[30];
- (2) 增量更新的方式.每次只需要计算新增数据对用户偏好的影响,这又需要思考如下两个子问题:(a) 如何快速计算新数据中用户偏好的变化量;(b) 如何解决用户原有偏好和更新后偏好的冲突^[68];
- (3) 并行化方式.这种方法主要包括两类.
 - 一类是普通方法的并行化^[69],主要是 Hadoop、stream 平台.但是学术界对其研究成果并不多,主要集中在工业应用领域;
 - 另一类是 GPU 并行化.随着深度学习的火热,由于 GPU 的高矩阵计算性能,使得 GPU 上的并行化变得流行.

由此可以看出:应用离线/在线框架的推荐系统将越来越普遍,最核心的还是模型实时更新的问题计算速度提升的问题.虽然通过硬件可以提升一定的性能,但是作为学术研究,主要还是需要研究更加实用的更新模型和设计更好的算法.

除此之外,用户的宽泛性意向还体现在对智能化推荐的需求上,如在城市智能导航应用中,需要用户自己了

解一些必要的信息(旅行攻略等),指定多种推荐约束后才能获得推荐结果.更多的情况是用户自己没有具体的计划,当前也没有自动化系统可以为旅行者提供个性化的行程推荐.对计算机而言,实现满足这样模糊又宽泛要求的综合推荐非常困难,所以在基于轨迹的移动推荐领域,满足宽泛的多维推荐需求也是一个热点问题.

6 结束语

随着移动设备和通信网络的进步和普及,基于位置的移动应用方兴未艾,促使移动推荐服务持续高速发展.鉴于用户行为数据的稀疏性,传统的移动推荐方法陷入性能瓶颈.以数据为驱动的思想催生了广义轨迹数据的定义和使用,即将用户的历史记录视作序列、语义和上下文的组合,这样的定义使得广义的轨迹有独特的序列信息,蕴含着强烈的时空关联性.相比于传统的 GPS 数据,广义的轨迹数据还拥有丰富的项目内容和用户行为信息.它不仅能够在物理世界中构建用户间的联系,还能够清晰地刻画用户在时空领域上的偏好,有助于研究者揭示用户行为演化的规律.因此,基于用户轨迹数据的移动推荐系统成为移动推荐领域研究的热点,并涌现出许多与移动轨迹相关的应用服务,如精准的个性化兴趣点推荐、旅游路线规划等.虽然目前已经取得了一定的成果,但仍然存在大量需要深入和扩展研究的内容,例如,如何有效缓解轨迹数据稀疏性问题、如何从广度和深度上有效利用轨迹数据、如何建立更有效的评价指标,等等.因此,基于用户轨迹数据的移动推荐系统具有重要的研究意义和广阔的应用场景.

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孟祥武(1966—),男,山东招远人,博士,教授,博士生导师,CCF 高级会员,主要研究领域为网络服务,用户需求,推荐服务.



张玉洁(1969—),女,副教授,主要研究领域为网络服务,用户需求,推荐服务.



李瑞昌(1982—),男,博士生,CCF 专业会员,主要研究领域为社会化网络分析,数据挖掘,推荐服务.



纪威宇(1987—),男,博士生,CCF 学生会会员,主要研究领域为网络分析,数据挖掘,推荐服务.