1. Demand：求解三维空间无碰撞的存续联通路径
2. Project Address：<https://github.com/bladesaber/MAPF_Pipeline>
3. Algorithm Structure:

算法组成：

1. 求解三维空间存续无碰撞路径
   1. 参考方案1: CBS[10] + A-star + CAT(Conflict Avoidance Table)[12]
   2. 参考方案2: Prioritized Planning[19, 20] + A-star

初步评价：方案1的求解路径为理论最短路径，但求解空间大，需要计算资源大，求解时间长。在方案初步结果确认后，可考虑添加Operator Decomposition[6,7,8]与Bypass[17]方法进行优化。方案2的求解路径为次优路径，但无法保证一定有求解结果。

1. 所得路径进行局部平滑
   1. 参考方案1：Hyprid A-star
   2. 参考方案2：Bezier Smoothing（以路径点为控制点）

初步评价：后续需要结合流体方面的函数设计

1. 管道效果可视化
   1. 参考方案1：基于PyVista库实现（参考https://docs.pyvista.org/）
   2. 参考方案2（候选）：基于Mayavi库实现
2. Plan：

2023-03-10：

1. 计划2023-04-01前完成算法组成（1）中两个方案（基于C++）。不确认在三维空间上A-star会不会由于搜索空间过大的问题导致崩溃，因此初期Grid空间设计为（50x50x50）先做尝试。
2. 之后需要一个粗糙的可视化代码（基于Python）。
3. 需要部分模拟应用场景的参数，对比以上两种算法求解该部分场景的Metric差异，以及对比人工设计与算法求解路径的差异（忽略局部路径平滑），已确认下一步是否继续进行。

2023-03-22：

一些优化的想法：

1. 将conflict检测更改为管道之间的距离阈值，当存在冲突时，使用Dijk（不需要Dijk，使用Max（X， Y）<=n即可）找出外层cell作为约束。因此与传统约束不同，的是一个集，而且与不是同一个集。
2. Theta\*是一个参考
3. Life-Long A\* 与 D\*，推荐Life-Long A\*

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3. Multi-Agent Pathfinding: Definitions, Variants, and Benchmarks, Roni Stern
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Search Based Method:

1. WHCA-star：Silver, D. 2005. Cooperative pathfinding. In Artificial Intelligence and Interactive Digital Entertainment (AIIDE), 117–122
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记录：

2023-03-06：

这段时间可以完成low-level的搜索方法与high-level规划方法的确定就很好了，第二个比较麻烦的方面就是要找到合适的参考代码并进行移植。对于传统的搜索方法的改进主要体现在：（1）启发式（2）限制branch数目（3）independent detection（4）创建window移动窗体（4）Operator decomposition （5）Conflict Avoid Table

2023-03-08：

与多智体路径规划不同的是，管道规划中行走过的路径不允许再被占据，所以Prioritized Planning 才会比较占主导，不过CBS应该仍然是最优结果的求解器。但我估计在三维上使用CBS会比在二维上开销大得多。

1. M-star似乎不适合于管道路径问题，因为路径不允许二次占据

2023-03-09:

总结来说，与常规的多智慧体路径规划相对比，主要是agent merge的操作失效了，（1） Operator Decomposition（单纯作为branch发散的问题方案使用）（2）ByPass方法 （3）启发式 这部分仍然是有效的。我的计划：

1. 完成两个求解器：
   1. 基于CBS + Search 的求解器 (CBS+A\*, ECBS)
   2. 基于 Prioritized Planning 的求解器 (PBS)
2. 我需要对比一下人工设计与算法设计的纯路径的差异
3. 路径平滑还是一个大问题，我预估这是一个Motion Planning Problem，我可能需要参考一下Hybrid A\* 或 基于simulation 的方法（例如Model Predictive Control，RRT\*）

2023-03-10:

A\*-star的变种应该是有用的：A-star（wiki）

2023-03-22：

目前完成了简单的Space-Time Astar与CBS的基础。在确认了方向无误后，先考虑完成一个完整的应用，先在小的测试环境上完成对（1）不同尺寸（2）平滑路径（3）合并与交集，三个问题的处理。

我认为我之前参考multi-agent path finding是有一定的偏差的，因为agent path finding的冲突需要考虑运动时间，但管道不需要考虑运动时间，因此可能Any-Angel Path finding与CBS混合是一个更合适的选择。

2023-03-23：

早期的两个思路是：（1）先用Astar搜索最优路径，然后做路径短接后处理，再在转角位使用特定的平滑方法。（2）直接在非完整的连续空间进行搜索

目前的三个问题主要是：（1）管道尺寸不一致，（2）平滑可能产生干涉或密集区域无法平滑

1. 关于LA-MAPF的问题，我认为如果使用disjoint splitting的方法则约束为一整个球体，否则用常规方式，则使用MC-CBS的方法，用交集约束

2023-03-24：

需求比我预想中多，而且由于我对目前的情况理解太少，似乎很多的需求缺乏启发式，它们的衍生是非线性的，那意味着无法在一开始的时候就知悉。这样迭代式的开发可能比想象中重要。

这个项目使用连续搜索比离散搜索更合适。MAPF-LNS有迭代形式的思想，我需要参考一下。

那些流体参数可能可以塞进路径的梯度优化里面。

可以通过全局梯度下降来平滑曲线。