ACS6124 Multisensor and Decision Systems
Part II: Decision Systems for Engineering Design

Assignment 2022/23

ACS6124 incorporates two assignments – one for each Part of the module. This document introduces the assignment for Part II, providing submission instructions, a detailed assignment briefing, and the marking criteria.

Assignment weighting:	50% of the module
Assignment released:	24 April 2023 (Monday, Week 9)
Assignment due:	12 noon, 22 May 2023 (Monday, Exam Week 1)
Format:	A report of 15 pages maximum (using a top and bottom margin of 1.5 inches, a left and right margin of 1 inch, text of size 12 point, with 1.5 line spacing). The report must be submitted electronically via BlackBoard.
Assignment code:	ACS6124-002

Penalties for late submission
Late submissions will incur the usual penalties of a 5% reduction in the mark for every working day (or part thereof) that the assignment is late and a mark of zero for submission more than 5 working days late. For more information, see:
https://www.sheffield.ac.uk/ssid/assessment/grades-results/submission-marking

Unfair means
This is an individual assignment. You should not discuss the assignment with other students or work together with other students in its completion. The assignment must be wholly your own work. References must be provided to any other work that is used as part of the assignment. Any suspicion of the use of unfair means will be investigated and may lead to penalties. For more information, see: https://www.sheffield.ac.uk/ssid/unfair-means

Extenuating circumstances
If you have any medical or special circumstances that you believe may affect your performance on the assignment then you should raise these with the Module Leader at the earliest opportunity. You will also need to submit an extenuating circumstances form. For more information, see:
https://www.sheffield.ac.uk/ssid/forms/circs

Help
If you have any questions on the assignment, please email me at: r.purshouse@sheffield.ac.uk

Feedback
Written feedback will be provided on Blackboard within 15 working days, in line with Department guidelines.

ACS6124多传感器和决策系统
第二部分：工程设计决策系统

Assignment 2022/23

ACS6124包含两个分配 一个用于模块的每个部分。本文件介绍了第二部分的作业，提供了提交说明、详细的作业简报和评分标准。

Assignment weighting:	**模块的50%**
Assignment released:	**2023年4月24日(星期一 第9周)**
Assignment due:	**2023年5月22日中午12时(考试第一周星期一)**
Format:	**最大15页的报告（使用1.5英寸的顶部和底部边距，1英寸的左右边距，大小为12点的文本，行距为1.5）。报告必须通过黑板以电子方式提交.**
Assignment code:	ACS6124-002

迟交的罚则

逾期递交的作品，如转让作品迟交，通常会被罚款5%，而逾期递交超过5个工作天的作品则会被罚款0%。有关更多信息，请参阅：https：www.sheffield.ac.ukssid评估等级-提交结果-标记

不公平的手段

这是一个单独的任务.你不应该与其他学生讨论作业，也不应该与其他学生一起完成作业。这项任务必须完全是你自己的工作.必须提供对作为作业一部分的任何其他工作的引用。任何怀疑使用不公平手段的行为都将受到调查，并可能导致处罚。有关更多信息，请参阅：https：www.sheffield.ac.ukssid不公平-手段

情有可原的情况

如果你有任何医疗或特殊情况，你认为可能会影响你在任务中的表现，那么你应该尽早向模块领导提出这些问题。您还需要提交一份情有可原的情况表格。有关更多信息，请参阅：https：www.sheffield.ac.ukssid表格

Help
如果您对作业有任何疑问，请发邮件给我：r.purshouse@sheffield.ac.uk
根据部门指引，我们会在15个工作天内在黑板上提供书面意见。

Assignment briefing

Imagine you are a recent graduate who has decided to build a start-up company working on decision systems for engineering design. Your first potential client is a company working on a new type of nuclear-powered vehicle. While their team is capable of designing the new powertrain, they have limited experience in designing the rest of the vehicle; for example they need to implement a suitable controller for their propulsion system and are not sure how it might affect the dynamic performance of the vehicle.

Your task is to convince them that your start-up company is perfectly suited to help them in the decision making process. To do that, they have asked you to prepare a report to highlight the capabilities of the tools you are proposing to use. Because at this stage they are reluctant to share their Simulink models, your pilot study will focus on tuning the gains for a Proportional-Integral (PI) controller, such that a feedback control system satisfies a set of requirements.

The system to be controlled, and the performance criteria against which a set of controller gains are assessed, are described in the Laboratory A instructions. The goals for the performance criteria are given in the instructions for Laboratory B.

During Laboratory A, you will learn about the relationships between the design variables and the performance criteria for the given system. In Laboratory B, you will attempt to optimize the gains to meet the goals for the performance criteria.

Following these laboratories, you need to write a report that would appeal to both the CEO of your potential client and their Chief Engineer. As you write, you will have further time to explore the system and perfect your design in the open Laboratory C. You need to convince the CEO that multi-objective optimization is the best way to approach the decision making. So far her company have used opinions from experts and developed prototypes to validate their designs. In addition, you need to have a technical part in which you show their Chief Engineer what your pilot study has managed to achieve, explaining any challenges encountered in satisfying all the requirements, and making recommendations for tuning options.

Your report should be structured as follows:

Title page including Executive Summary (**1 page**)
Summarise the outcomes of the tuning process and recommendations for PI gain settings in **under 300 words**. This section does not contribute to the page limit for the report.

Section 1: Multi-objective optimization for Engineering Design (**3 pages**)
Write a brief introduction to Decision Systems for Engineering Design. Explain how it compares with other approaches used in decision making and give five examples from the literature where it has been used for vehicle design. Draw a comparison between three classes of population-based optimizers that can be used as the engine for a multi-objective optimization process. Explain the main differences in their approach to find a candidate approximation set.

Section 2: Problem Formulation (**1 page**)
Express the problem in formal mathematical terms.

Section 3: Sampling Plan (**2 pages**)
Show at least three different sampling plans and analyse their space-filling performance. Identify a sampling plan to take forward.

任务简报会

想象一下，你是一个刚毕业的人，他决定建立一个创业公司，致力于工程设计决策系统。您的第一个潜在客户是一家致力于新型核动力车辆的公司。虽然他们的团队能够设计新的动力总成，但他们在设计车辆其余部分方面的经验有限;例如，他们需要为他们的推进系统实施一个合适的控制器，并且不

你的任务是说服他们，你的创业公司非常适合在决策过程中帮助他们。为此，他们要求您准备一份报告，突出您建议使用的工具的功能。因为在这个阶段他们不愿意分享他们的Simulink模型，所以您的试点研究将重点放在调整比例积分(PI)控制器的增益，以便反馈控制系统满足一组要求。

要控制的系统，以及评估一组控制器增益的性能标准，在实验室a说明中描述。性能标准的目标在实验室B的说明中给出。

在实验室A期间，您将了解设计变量与给定系统的性能标准之间的关系。在实验室B中，您将尝试优化增益以满足性能标准的目标。

在这些实验室之后，您需要编写一份报告，以吸引潜在客户的首席执行官和他们的首席工程师。当你写的时候，你将有更多的时间在开放实验室中探索系统并完善你的设计C.你需要说服首席执行官多目标优化是接近决策的最佳方式。到目前为止，她的公司已经使用专家的意见和开发原型来验证他们的设计。此外，您需要有一个技术部分，在其中向他们的首席工程师展示您的试点研究已经成功实现的目标，解释在满足所有要求时遇到的任何挑战，并为调优选

您的报告的结构应如下:

标题页包括行政摘要(1页)
总结调整过程的结果和PI增益设置的建议在300字以下。此部分不会影响报表的页数限制。

第一节工程设计的多目标优化（3页）
写一篇关于工程设计决策系统的简介.解释它与决策中使用的其他方法的比较，并从文献中给出它用于车辆设计的五个例子。绘制三类基于总体的优化器之间的比较，这些优化器可用作多目标优化过程的引擎。解释他们找到候选近似集的方法的主要差异。

第二节：问题制定（1页）

用正式的数学术语表达问题。

第三节抽样计划(2页)
显示至少三种不同的采样计划并分析其空间填充性能。
确定要推进的抽样计划。

Section 4: Knowledge Discovery (**2 pages**)
Use the evaluations from the chosen sampling plan to describe the relationships between the design variables and performance criteria.

Section 5: Optimization Process (**2 pages**)
Describe the optimization approach used and how goals were incorporated into the process.

Section 6: Optimization Results (**2 pages**)
Show the results of the optimization process, indicating whether or not the goals have been met, and the trade-offs inherent to the problem.

Section 7: Recommendations (**1 page**)
Based on the knowledge discovery and optimization results, make recommendations for PI controller options for consideration by the Chief Engineer.

Section 8: Conclusions (**1 page**)
Link the results of your study with the vehicle propulsion problem your client is keen to solve. How would you apply the same methodology for their problem? Indicate at least two other decision systems tools that you propose to use to help them in their design problem.

Bibliography
Include references to any works used in the report. This section does not contribute to the page limit for the report.

Appendix
Provide your Matlab code listings as an appendix to the report. The appendix does not count towards the page count for the report.

第四节：知识发现（2页）
使用所选抽样计划中的评估来描述设计变量和性能标准之间的关系。

第五节：优化过程（2页）
描述所使用的优化方法以及如何将目标纳入流程。

第六节：优化结果（2页）
显示优化过程的结果，表明目标是否已经达到，以及问题固有的权衡。

第7节：建议（1页）
根据知识发现和优化结果，对PI控制器选项提出建议，供总工程师考虑。

第8节：结论（1页）

将您的研究结果与您的客户渴望解决的车辆推进问题联系起来。你将如何为他们的问题应用相同的方法？指出至少两个其他决策系统工具，你建议使用，以帮助他们在他们的设计问题。

Bibliography
包括对报告中使用的任何作品的引用。此部分不会影响报表的页数限制。

Appendix
提供您的Matlab代码列表作为报告的附录。附录不计入报告的页数。

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Marking criteria

The assignment will be marked out of 100. The marking criteria below provide guidance on the relationship between the quality of submission and the marks awarded. Note that the quality statements are *indicative* only – the actual mark awarded will be a holistic judgment of the *overall* quality of submitted work.

Mark awarded	Expected attributes of the technical report
70-100	• An executive summary that succinctly summarises the findings of the tuning process and recommendations for future action. • A coherent introduction to decision systems for engineering design, contrasting multi-objective optimization to other approaches to decision support. Accurate description and comparison of the three major classes of multi-objective optimizer. • A problem formulation that correctly interprets the problem features in the language of constrained multi-objective optimization, including identification of design variables, parameters, objectives and constraints. • A set of at least three sampling plans that have been correctly assessed in terms of their space-filling properties. • Appropriate and creative data mining and visualisation of the sampling plan evaluation, identifying key relationships between design variables and objectives (e.g. regions of stability, trade-offs between aspects of transient performance). • A clear description of the optimization approach used, including how Chief Engineer preferences were incorporated into the search process. • Appropriate and creative data mining and visualisation of the results of the optimization process, identifying the level of success achieved and areas of conflict that are as yet unresolved. • A coherent and credible set of recommendations for the controller gain settings, reflecting the results of the knowledge discovery and optimization processes. • Compelling association of the study findings to the client's vehicle design problem, indicating how the same methods could be used to deliver benefits, and highlighting two other decision systems tools that would be used alongside these methods. • Well-presented report, with appropriate use of labelled figures and few spelling or grammatical errors.
60-69	• An executive summary that succinctly summarises the findings of the tuning process and recommendations for future action. • An introduction to decision systems for engineering design, and accurate description of the three major classes of multi-objective optimizer. • A problem formulation that correctly interprets the problem features in the language of constrained multi-objective optimization, including identification of design variables, parameters, objectives and constraints. • A set of at least three sampling plans that have been correctly assessed in terms of their space-filling properties. • A creditable attempt to identify key relationships between design variables and objectives through visualisation of the sampling plan evaluation (e.g. regions of stability, trade-offs between aspects of transient performance). • A clear description of the optimization approach used. • A creditable attempt to analyse the results of the optimization process, identifying the level of success achieved. • Recommendations for the controller gain settings that are largely grounded in the results of the knowledge discovery and optimization processes. • Linkage of the study findings to the client's vehicle design problem, highlighting at least one other decision system tool that would be used alongside these methods. • Generally well-presented report, with appropriate use of labelled figures and few spelling or grammatical errors.

评分标准

分配将被标记为100。以下的评分标准就提交的质量与所获分数之间的关系提供指引。请注意，质量声明只是指示性的–实际授予的标记将是对提交工作的整体质量的整体判断。

获颁马克	技术报告的预期属性
70-100	• 一份执行摘要，简明扼要地总结了调整过程的结果和对未来行动的建议。 • 一个连贯的介绍决策系统的工程设计，比较多目标优化其他方法的决策支持。准确描述和比较三大类多目标优化器。 • 用约束多目标优化的语言正确解释问题特征的问题公式，包括识别设计变量，参数，目标和约束。 • 一组至少三个抽样计划，已正确评估其空间填充特性。 • 抽样计划评估的适当和创造性的数据挖掘和可视化，确定设计变量和目标之间的关键关系（例如稳定性区域，瞬态性能方面之间的权衡）。 • 清楚描述所使用的优化方法，包括总工程师偏好如何纳入搜索过程。 • 对优化过程的结果进行适当和创造性的数据挖掘和可视化，确定所取得的成功水平和尚未解决的冲突领域。 • 一组一致且可信的控制器增益设置建议，反映了知识发现和优化过程的结果。 • 将研究结果与客户的车辆设计问题紧密联系起来，说明如何使用相同的方法来实现收益，并突出显示将与这些方法一起使用的另外两个决策系统工具。 • 精心呈现的报告，适当使用标记的数字和很少的拼写或语法错误。
60-69	• 一份执行摘要，简明扼要地总结了调整过程的结果和对未来行动的建议。 • 介绍了工程设计的决策系统，并准确描述了多目标优化器的三大类。 • 用约束多目标优化的语言正确解释问题特征的问题公式，包括识别设计变量，参数，目标和约束。 • 一组至少三个抽样计划，已正确评估其空间填充特性。 • 通过可视化抽样计划评估来确定设计变量和目标之间的关键关系（例如稳定性区域，瞬态性能方面之间的权衡）的可信尝试。 • 使用的优化方法的明确描述。 • 一个可信的尝试分析优化过程的结果，确定成功的水平。 • 控制器增益设置的建议主要基于知识发现和优化过程的结果。 • 将研究结果与客户的车辆设计问题联系起来，突出显示将与这些方法一起使用的至少一个其他决策系统工具。 • 报告一般呈现良好，适当使用标记的数字和很少的拼写或语法错误。

Mark awarded	Expected attributes of the technical report
50-59	• An executive summary that includes an attempt to summarise the findings of the tuning process and makes recommendations for future action. • An introduction to decision systems for engineering design, with an accurate description of at least one of the classes of multi-objective optimizer. • A problem formulation that interprets the problem features in the language of constrained multi-objective optimization, but where the formulation may contain some missing or unclear elements. • An appropriately visualised sampling plan. • Some attempt to identify key relationships between design variables and objectives through visualisation of the sampling plan evaluation (e.g. regions of stability, trade-offs between aspects of transient performance). • A description of the optimization approach used, although some aspects may not be clearly described. • A creditable attempt to analyse the results of the optimization process, identifying the level of success achieved. • Recommendations for the controller gain settings that are largely grounded in the results of the knowledge discovery and optimization processes. • Some indication of how the study findings link to the client's vehicle design problem, indicating how the same methods could be used to deliver benefits, highlighting at least one other decision system tool that would be used alongside these methods. • Generally well-presented report, with appropriate use of labelled figures and few spelling or grammatical errors.
40-49	• An executive summary that provides a readable summary of the report, but is lacking focus on findings and recommendations. • An introduction to decision systems for engineering design, with a description of at least one of the classes of multi-objective optimizer. • A problem formulation that interprets the problem features in the language of constrained multi-objective optimization, but where the formulation may contain some missing, unclear elements, or incorrect elements. • An appropriately visualised sampling plan. • Lacking a convincing analysis of the key relationships between design variables and objectives through visualisation of the sampling plan evaluation (e.g. regions of stability, trade-offs between aspects of transient performance). • A description of the optimization approach used, although some aspects may not be clearly described. • Results of the optimization process are presented, but these are not analysed. • Lacking recommendations for the controller gain settings, or recommendations that do not relate to the results of the knowledge discovery and optimization processes. • Lacking indication of how the study findings link to the client's vehicle design problem, although highlighting at least one other decision system tool that would be used alongside the methods employed. • Issues with the presentation of the report, with numerous grammatical errors and figures that are missing labels.

获颁马克	技术报告的预期属性
50-59	• 执行摘要，包括试图总结调整过程的结果，并为未来的行动提出建议。 • 介绍用于工程设计的决策系统，并准确描述多目标优化器的至少一个类。 • 用约束多目标优化的语言解释问题特征的问题公式，但其中公式可能包含一些缺失或不清楚的元素。 • 适当可视化的抽样计划。 • 一些人试图通过可视化抽样计划评估来确定设计变量和目标之间的关键关系（例如稳定性区域，瞬态性能方面之间的权衡）。 • 使用的优化方法的描述，尽管某些方面可能没有被清楚地描述。 • 一个可信的尝试分析优化过程的结果，确定成功的水平。 • 控制器增益设置的建议主要基于知识发现和优化过程的结果。 • 一些迹象表明研究结果如何与客户的车辆设计问题联系起来，表明如何使用相同的方法来提供收益，突出显示将与这些方法一起使用的至少一个其他决策系统工具。 • 报告一般呈现良好，适当使用标记的数字和很少的拼写或语法错误。
40-49	• 执行摘要提供了可读的报告摘要，但缺乏对调查结果和建议的关注。 • 介绍用于工程设计的决策系统，并描述多目标优化器的至少一个类。 • 用约束多目标优化的语言解释问题特征的问题公式，但其中公式可能包含一些缺失的，不明确的元素或不正确的元素。 • 适当可视化的抽样计划。 • 缺乏通过可视化抽样计划评估（例如稳定性区域，瞬态性能方面之间的权衡）对设计变量和目标之间的关键关系进行令人信服的分析。 • 使用的优化方法的描述，尽管某些方面可能没有被清楚地描述。 • 给出了优化过程的结果，但没有分析这些结果。 • 缺乏对控制器增益设置的建议，或与知识发现和优化过程的结果无关的建议。 • 没有说明研究结果如何与客户的车辆设计问题联系起来，尽管强调了至少一个其他决策系统工具，该工具将与所采用的方法一起使用。 • 报告的呈现问题，有许多语法错误和数字缺少标签。

Mark awarded	Expected attributes of the technical report
0-39	• Missing or incoherent executive summary. • Lacking an introduction to decision systems for engineering design and/or substantial inaccuracies in the description of multi-objective optimizers. • Missing or incoherent problem formulation. • Some evidence of a sampling plan, but unclear what this looks like. • Lacking a convincing analysis of the key relationships between design variables and objectives through visualisation of the sampling plan evaluation (e.g. regions of stability, trade-offs between aspects of transient performance). • Missing or incoherent description of the optimization approach used. • Missing the results of the optimization process. • Lacking recommendations for the controller gain settings, or recommendations that do not relate to the results of the knowledge discovery and optimization processes. • Lacking indication of how the study findings link to the client's vehicle design problem and absence of consideration of other decision system tools that could be used alongside the methods employed. • Major issues with the presentation of the report, with numerous grammatical errors and figures that are missing labels, such that the meaning in the report is hard to discern.

获颁马克	技术报告的预期属性
0-39	• 缺少或不连贯的执行摘要。 • 缺乏工程设计决策系统的介绍，或者在多目标优化器的描述中存在重大不准确性。 • 缺失或不连贯的问题制定。 • 抽样计划的一些证据，但不清楚这是什么样子。 • 缺乏通过可视化抽样计划评估（例如稳定性区域，瞬态性能方面之间的权衡）对设计变量和目标之间的关键关系进行令人信服的分析。 • 使用的优化方法的缺失或不连贯的描述。 • 缺少优化过程的结果。 • 缺乏对控制器增益设置的建议，或与知识发现和优化过程的结果无关的建议。 • 没有说明研究结果如何与客户的车辆设计问题联系起来，也没有考虑可以与所采用的方法一起使用的其他决策系统工具。 • 报告提出的主要问题 有许多语法错误和缺少标签的数字 使报告的意义难以辨认。

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