ADJ - Ruleset 1v3

Summary: In this handout, we review the motivation and basic ideas of the ADJ framework, and discuss general rules for submissions.

1 Introduction

The goal of ADJ assignments is simple: they are a way to practice **strengthening and defending** your ideas through engineering design, particularly when applied to **open-ended and ill-defined** problems. There are two basic concerns here: 1) we need to be able to produce solutions to problems that are "incomplete". 2) we need to be able to produce solutions that stand alone and which we have true confidence in. This means being able to produce complete results - rather than just a design, we must also analyze an incomplete problem and justify its solution - and to be able to communicate them in a clear way.

The above may seem like too much work. Let's consider though: many of the problems we see in courses are "well-defined". For example, if you are asked to find the Big-Oh of a Java method, you have everything you need to solve the problem, and even will have some ideas of how to do so. You can likely generate an answer by just looking at the code. Better yet: there is exactly one answer to the problem ("It's $O(n^2)$!"). This means that both you can the grader will easily agree that you are (I hope!) correct. Unfortunately, not all problems look like this. *Real-world problems tend to be open-ended and ill-defined ("incomplete").* There is no one ideal solution that we find (or that a grader can check against). Unfortunately, these types of problems are neglected in coursework, which instead focuses on simpler problems that are closed-ended and well-defined (like Big-Oh above). This is problematic - you may not gain as much experience as you need with solving realistic problems. This assignment (and ADJ in general) is an attempt to address that issue. Now before we get all the way to true real-world problems, let's consider something milder: an essay prompt that is somewhat incomplete.

In an essay homework question, the student is asked to provide a solution to a short problem statement that often has some level of open-endedness or ill-definedness. The student provides an idea that answers the question, and if it looks good, the grader will give marks. But: was it really a good answer? How can someone (student or grader) even evaluate the correctness of answer? If it's not a numerical answer, is it at all obvious? It's not uncommon to look at a graded question, and think: "why didn't they like that???" You aren't there in the room to point out stuff to the grader: your idea must be able to stand alone. The typical issue is that the answer is ambiguous - we inadvertently may have skipped analysis and justification.

For some examples of answers which could be strengthened, let's consider the following legacy exam question on threading (M6):

> Consider the algorithmic task of changing a photograph into the art style known as cubism. In such a filter, regions of pixels are transformed into rectangular regions with a single color. For example, the following image:
>
>  would be filtered to 
>
> Say we want to design a image filter algorithm to apply a cubism filter. Of the five issues in multi-core programming, which is the most problematic for multi-threading this problem? Justify.

There are many ways to answer this question. Per the lecture on this material, five different issues were discussed: Identifying Tasks, Balance, Data Splitting, Data Dependency, and Test and Debugging. Some sample answers follow:

1. "Data splitting" **Evaluator Concerns:** Is this right? This answer doesn't include justification. What if it's a guess? The reader will have questions, "Why not pick something else?"

2. "Communication between threads as some of the image depends on the area outside of the assigned portion in a single thread. The final result may be different depending on how the combination of the threads into the 2d array representing the image is processed." **Evaluator Concerns:** Communication isn't one of the five issues, so even if the idea is good, it doesn't answer the specific question being asked. The second sentence starts to describe something that sounds like a race condition, but without using the proper terminology it's hard for the reader to identify what's new and why it's being described. Here, we intended to strengthen our answer but we've sort of gotten lost.

3. "Balance could come up if the image is large and the size of the rectangles vary in size a great deal. Then we risk one thread getting a bunch of big rectangles and another a bunch of small ones."**Evaluator Concerns:** This isn't really an answer - the fundamental idea is correct but it does not take a stance on "most problematic", rather it makes the smaller claim that something might be an issue. But: our idea is correct and could be made strong. We also see that the answer says "size of rectangles vary in size", although the image has them all the same size (good thought but perhaps a mismatch in problem understanding?).

4. "Here we would have a problem with data splitting. If two threads were to be working on the same portion of the bitmap, then you would have the same pixels trying to be modified and would end up with a mesh of colors rather than two distinct cubes." **Evaluator Concerns:** The argument is predicated on "two threads working on the same portion". This is a true statement, but specific to a particular algorithm which solves this problem. This is a bit dangerous to do since the prompt asked us about the problem in general. The sentence also mentions "two distinct cubes" - what does this mean? There are many cubes in the image. Again, the reader will have questions that the answer doesn't address.

All of these are examples of answers that make an effort to answer the stated problem but which a particularly annoying evaluator could find fault in. The issue is that while these answers are potential solutions for the problem, they are not self-supporting. They do not justify "I am *the* answer", but rather "I am *an* answer." In this assignment, we want to do better. Although there several different concerns with the answers above, two specific things stand out: 1) The problem is not clear in the head of the problem solver. (Or perhaps they have not communicated that clarity.) This leads to creating solutions that don't solve the problem. 2) It is not clear that something that looks like a solution, really is the solution. These concerns relate to (no surprise): the missing **analysis** and **justification** needed for more realistic problems.

This document is separated into three sections: Introduction, Base Requirements, and Further Requirements. You have almost finished reading the Introduction section already. In Base Requirements, we will discuss the minimum requirements for submissions to be graded. Lastly, Further Requirements discusses solution requirements which will be reviewed during grading.

1.1 ADJ Homework Format

In these assignments, you will be asked to apply ADJ. ADJ is a simple method for performing structured problem-solving using three steps. ADJ focuses on understanding a problem in three different steps (analysis, design, and justification), and generating information at each one. "This encourages a structured view of problem-solving and ensures evidence is generated for distinct steps in problem solving. In a technical skills course, specific techniques would be potential activities that can be practiced and assessed in the context of using ADJ to solve a problem. Although ADJ can be used for any problem, it provides the most benefit for those which are complex and context rich. A typical ADJ problem is open-ended and ill-defined, potentially incomplete, with real-world context provided by itself, or in coordination with other resources when additional

scaffolding is needed. To solve these types of problems, we would use the following steps: Analysis, Design, and Justification. **Analysis:** a translation of the original ill-defined problem into requirements that can be evaluated. **Design:** a solution to the problem being solved. **Justification:** an argument that supports a design as being superior to other potential designs that also satisfy the analysis requirements."[1]

Let's consider the format of an ADJ-style answer. Let a problem which you are answering be called P. A solution to P is compartmentalized into three sections (analysis, design, justification), each worth different point values. These internal values are given in the problem sets.

- **Analysis (call it A):** In this section, you should define your immediate problem, and any useful corollaries. The answer should be in terms of the problem itself, and not be biased in any towards a possible solution. It is possible that some portions of your analysis will not be needed later - indeed, this is expected since otherwise we do not have multiple inputs to a design thought process, meaning there is only one choice, and so the answer would be immediate.
- **Design (call it D):** In general, design has the flavor of picking some choice among a set of possible options. Design is subjective - in and of itself, we cannot state that a particular design is best. This section should take an axiomatic (built from the results of the analysis) approach to constructing a solution which meets a metric (defined in analysis) by which a design may be judged to provide a satisfactory/optimal answer to P. (For some problems, design will take the form of designing an argument which states a position on a claim made in the question prompt. In others, it will literally mean designing an algorithm.)
- **Justification (call it J):** Given that we have a design, we want to argue that this design is: a) well-founded, sound, and solves the problem, and b) is the optimal design for the problem. A justification is an easily verifiable piece of information (here: readable by a 3rd party) that shows this statement is correct (think of a justification as a certificate for the goodness of your design).

Overall, we wish to show that a problem under analysis (A), soundly yields a design (D), such that the design is the optimal solution to the problem. The justification (J) is a sound argument that the design is the optimal solution for the problem given the analysis. Hence your answer to problem P has three parts: A, D, *and* J.

1.1.1 Background Knowledge

We call the corpus of background knowledge K. K represents the set of ground truth facts that may be taken as assumptions/axioms in your analysis. Hence, we more accurately state: $Analysis(P|K) = A$. K will be maintained by the instructional staff as a document on the course Canvas. K is initially empty. You can and should ask the instructional staff to add entries to K! (Asking for additions to K is unlimited.)

2 Basic Paper Requirements

As a base expectation, your submissions must demonstrate both attention to instructions, and professionalism. Specifically (and exhaustively), we require the following to assign a non-zero grade to a submission:

1. Answers must be clearly labeled as **analysis**, **design**, or **justification**, and follow the overall goal for each subsection mentioned in Subsection 1.1.
2. Solutions must be in the spirit of the problem. Do not submit solutions to some "clever" edge case of the problem(s).
3. Proper spelling and grammar. Assignments must not have more than three spelling errors per page, or more than one major grammar error per page (which distracts from readability).
4. Writing must be clear and semi-formal. Do not use first person or ambiguous writing. Submit a paper, not slides or a presentation.

[1] https://ieeexplore.ieee.org/document/9454055

5. The submissions rules in the PDF for the problem set are followed exactly.

Penalty: Failing to following any of the basic requirements laid out in this section, will result in students receiving an automatic zero grade on the assignment.

If you are concerned that your solutions do not met the above requirements for grading, you may bring them to office hours for a pre-check to confirm that they are ready to submit.

3 Further Requirements

1. Any assumptions you make in analysis should be both explicitly stated to be assumptions, and reasonable from the prompt. **Penalty:** points will be deduced per standard review of your logic.

2. **Use paragraphs as appropriate. If you give nothing but bullet points then your solution is likely a summary, not a solution, and will not be worth much credit.**

3. Do not submit anything that you do not understand, or which you do not think actually works. Your explanation must convince the reader that you know and understand what is happening. **Penalty:** zero grade on that subsection (i.e.,. analysis, design, justification).

   Note: If you are unable to produce an answer to a subsection, then you may optionally write "We are not able to produce a satisfactory answer for this portion.", in which case you will receive half a point for giving an accurate statement and assessment.

4. You may not use explicit information outside of K. Citations and references are not permitted. This includes the textbook, course material, internet sources, etc. **Penalty:** zero grade on that subsection.

   Corollary: since ASU academic integrity policy restricts use of anything not cited, this means your solution must be entirely of your own construction.

3.1 Self-Check

- Per the above rules, question 1 on ADJ problem set 1 is unsolvable as of 9/20/21 at 9:30pm (AZ). As a way to ensure you understand these rules, try to figure out the problem and then ask the instructional staff to check your idea (don't post in the general Slack channel so as not to spoil it).

3.2 Grading

The basic metric for grading is: *your arguments must be well-founded, sound, and solve the problem stated in an optimal way.* Informally, this statement can be understood to imply that your problem should be defensible from alternative answers. The requirements for each individual problem are broken down in further detail as a rubric on Canvas assignment page.

3.3 Notes and Suggestions

- **Length:** unless otherwise stated, the suggested length of a solution to a specific problem is one or two pages (1" margin, 12 point font). Some problems will be shorter, some longer. In general, the ideal length of an answer is what is needed to answer it soundly and concisely.

- **Human Language:** human language is an inherently under-specified way of communicating knowledge. Be careful with your words, and their meaning. As a rule, there is no reason to assume that any reader will share your definitions of the concepts being used. Also be careful with the implicit semantics of words - words means things. Write what you mean, and mean what you write. Avoid global quantifiers.

- **Assumptions:** do not make arbitrary or implicit assumptions. Either make explicit reasonable assumptions, or ask for clarification from the instructor so that they update K.