Assignment HMMs tips and FAQ

This is a compilation of tips and frequently asked questions regarding Assignment HMMs. Please study it in detail **before** you ask a question online on Canvas. It might already have been answered.

We are covering the following categories:

Technical questions: These questions center around technical issues such as "How do I get the code to run on my operating system?".

Theoretical questions: These questions center around theoretical issues such as "I did not understand the difference between observations and states, is there any?". Some theoretical misunderstandings might lead to practical problems, so check this one as well when you are in trouble!

Practical questions: These questions center around practical issues such as "What do I have to do to achive X grade"?

Kattis questions: These questions center around Kattis specific issues such as "What does the feedback from Kattis mean"?

1 GENERAL INFORMATION ABOUT DEBUGGING

Please, consider these tips when building your program for the HMM asignment.

1. When dealing with probabilistic model programming, such as the HMM model, the first and foremost thing to check is that your probabilities are summing up to 1 and if they are between $[0, 1]$.

1.1. Try to reduce the complexity of your model, if the number of variables is something that you can set beforehand.

1.2. Try to think about what kind of subset of events you are considering so as to define the normalizing constant, your probability should sum up to 1 inside this subset of events.

1.3. Try to utilize a toy example, so that you can calculate the probabilities by hand. In other words, try to come up with some key low-dimensional emission and observation matrices, i.e., define some useful examples of transition matrices that converge and that does not converge along with multiplications (so-called transient and recurrent states).

1.4. Try also to check the sum for the cases that should not necessarily sum up to 1. This is not a necessary condition, but if those cases are constantly summing up to 1 this could indicate that something is wrong in your algorithm.

> **NOTE 1:** Debugging checking whether rules are satisfied is a good strategy. However, sometimes your bug might be hidden inside intrinsic relations. That is why it might be important to check if something that is not a rule is acting like it was a rule.

> **NOTE 2:** Checking things that should occur are as important as checking things that should not occur.

> E.g. 1: In a conditional probability the probability of the measured variable should sum up to 1 on the same fixed conditioning.

> E.g. 2: Also check if the sum of probabilities of a fixed measured variable conditioned with two different values is giving always a same number or 1 for different seeds or trials, this is something that should not occur.

2. Try to debug by considering smartly potential problematic cases and those cases that are not problematic (keep note of the seeds used in those cases and recheck their results often).

3. First of all try to implement everything straight from the equations. Do optimisations later, i.e., translate everything to matrix computations once you are sure that your code is doing what is intended to do.

4. Try to write matrix computations as simple as possible.

5. Try to put as much as you can in matrix computation.

2 STABILITY OF CALCULATIONS

6. Make sure you have put the epsilon in the right place of the calculations. Do not put it too much not to make it unstable the computations and put it in the key places.

7. Have special attention with several products sequentially. What could you do to avoid this? Try to avoid zero denominators. Once you have a working code, then you can optimise.

8. Is there more than 1 way to solve the scaling of your problem? If yes, try at least 2 different ones to compare how your code responds to it.

3 INFORMATION ABOUT DEBUGGING ON KATTIS

9. Kattis reproduces your code in a diverse set of environments. Try to simulate those environments by yourself, i. e., try to create different scenarios. A good and fast hint is to make a combinations of the scenarios that you already have by adding up or mixing. Try also to insert noise in different levels of variance to put your code to the limits of testing.

10. For debugging Fishing derby try to check which part of the task your code is focusing more. Try to improve the task that it is worst at. This should improve globally your computations.

4 TECHNICAL QUESTIONS

These questions center around technical issues such as "How do I get the code to run on my operating system?"

Question 0: HMM: To pass the tests on Kattis, where should we read the input from, is it in the args from main(args[]) or in the console or anywhere else? You need to take in the inputs from the standard input (the console). We recommend to work with this system on your computer as well so that you do not need to adjust too much when moving to Kattis.

Question 1: HMM: Can someone explain the exact meaning of the test cases? How will we interpret them? You should not concern yourself with the structure of the test cases. Read the files in the code skeleton carefully. They will take care of the parsing.

Question 2: HMM: The solutions obtained by my code are really similar to the ones shown as an example but not exactly the same (e.g., 0.543726 vs 0.545455), is that an issue? The most probable reason for these slight differences are that you might not be using double precision for everything or/and there are some implicit castings on your code. However, if passing the Kattis test is your concern, these differences should not be a problem.

Question 3: HMM: My solutions are right but I can not pass the Kattis tests. Please make sure you are outputting the answers correctly. I.e.,

- In Python correct formating can be achieved with: `print(' '.join(map(str, result)))`

Just use the standard error outputs for debugging.

Question 4: HMM0: We should get "1 3 0,3 0,6 0,1" but we obtain "1 3 0,30000000000000004 0,6 0,1" instead because of the doubles. Do we need to round it up to 0,3? There is no need to round in this case. The most probable reason for these slight differences are that you might not be using double precision for everything or/and there are some implicit castings on your code. However, if passing the Kattis test is your concern, these differences should not be a problem.

Question 5: HMM1: I am obtaining ArrayIndexOutOfBounds in HMM1 for test case 4, despite passing the previous first cases. Which could be the problem? Think about what are rows and what are columns in the observation matrix. Make sure that your code handles non-square matrices.

Question 6: HMM2: If there are multiple paths with the maximum probability, should we print all of them or just one? The Kattis tests do not test for multiple paths.

Question 7: HMM2: Kattis still gives me "wrong answer" for the second test of Viterbi. Can I get an explanation on what exactly argmax for $delta_{idx}$ is? I think something might be wrong when calculating the path, although I get the correct answer for the sample input. Most errors arise due to incorrect or missing backtracking. When you are computing $\delta_t(i)$ you have to take into account which was the most like preceding state. You store the number of that state into another data structure $\delta_t^{idx}(i)$. That way, if you know that for time t and state i you come from state k in (t-1), then $\delta_t^{idx}(i) = k$. Finally you need to backtrack. So, in simple terms, the "argmax for δ_t^{idx}" gives you the most probable previous state given the current observation, where you are (in t) and the matrices.

Question 8: HMM3: Shall we use the scaling like in the stamp tutorial? (pseudocode page 13) In HMM3 the length of the observation sequence is quite long (significantly longer than in HMM1). Using some kind of scaling might definitely be useful. It might also be useful to try to implement a solution without any scaling to see whether and which kinds of problems arise.

Question 9: Fishing derby: What do you mean by "each species has their own swimming patterns"? Does it mean for each fish only follow one swimming pattern in each round, or could it be a few patterns instead? Each species has a few characteristic swimming patterns and a fish can swim in one of its characteristic swimming patterns or a combination of those. It could be that the fish of the same species may follow different swimming patterns in a particular round.

Question 10: Fish Derby: Sometimes I get wrong answer even though my output format is correct. Why could that happen? Please be careful with the return deadlines. Those make sure your program

does not take too long. If you do not respect them, there is a forceful return request from the server which might yield to a wrong answer.

Question 11: Fishing Derby: Is the species of fish relevant to the task at hand?
The specific type of fish is irrelevant for the problem. You only need to know that there are several fish and that they behave differently

5 Theoretical questions

These questions center around theoretical issues such as "I did not understand the difference between observations and states, is there any?". Some theoretical misunderstandings might lead to practical problems, so check this one as well when you are in trouble!

Question 0: In the Stamp introduction, it is mentioned that uniform values in A, B and π would result in a local maximum for lambda estimation. Why exactly is that, and why would it not happen in some other case where the values are not uniform? The uniform distributions in the parameters will render all states and observations equally likely such that the updates of A, B and π in each iteration will be uniform. Thus, we are not able to move away from these parameters. Say, you have observed *head*, *head*, *head*, *head*, *head*, *tail* (observations) from one of two coins (hidden state). Obviously, you see that at least one coin turns out to be *head* more often. Under a uniform distribution however, any combination of the two coins will result in the same distribution over the observations. Thus, the uniform distribution explains the data so well, that the learning algorithm will not more away from it. We are never guaranteed not to end up at a local maximum, as the Baum-Welch algorithm is not guaranteed to convergence to the true values. However, the likelihood that you hit such a spot in the parameter space randomly is pretty low.

Question 1: Could we use the gammas instead of Viterbi to determine the most likely state sequence? The gammas give you the most probable hidden state at each time step. That means that you might get an impossible hidden state sequence as a solution. The probability of transition from state 1 to state 2 might be zero, but the gammas might still indicate that state 1 is most probable at time t and state 2 s most probable at time $t+1$. Viterbi guarantees a possible and the most likely state sequence.

Question 2: I have troubles passing the Kattis tests on estimating a sequence of states. Please, take a closer look at how the Viterbi algorithm is defined in Section 2.4 of the assignment description. Play special attention at the dimensions of each of the arrays.

Question 3: My probability computations are OK for short sequences but get really wrong when scaling to longer ones. Why could that be? Please remember the underflow problem taught at the lectures. Try to overcome this problem either by working in the logarithm world or by scaling.

6 Practical questions

These questions center around bureocratic issues such as "What do I have to do to achive X grade"?

Question 0: Do we need to submit the assignment questions somewhere? No, but you should bring them to the presentations and be ready to show your understanding of them.

Question 1: Do we need to upload any code in Kattis for a C grade? No. It is sufficient to have conducted the experiments on a computer and be ready to answer the questions on the presentation.

Question 2: Is the last submission to Kattis the one that counts? No. We count the submission that you state when you book a slot for the oral presentation/redovisning. Make sure to indicate the right Kattis ID in your presentation slot booking!

7 KATTIS QUESTIONS

These questions center around Kattis specific issues such as "What does the feedback from Kattis mean"? Kattis feedback is very sparse in nature, this is on purpose as it is not a debugging tool. Please only submit to Kattis if the problem works on your local machine.

Question 0: What does the feedback from Kattis mean? The official answer documentation can be found here: `https://open.kattis.com/help/judgements`

Question 1: I keep getting "Compile Error" from Kattis but it works fine on my machine? Check if you included an exotic library. Kattis does not have Windows specific library for example. Submit the Skeleton without your code and add library's one by one to find the culprit and solve the problem without that specific library.

Question 2: I changed stuff in the game specific files but the changes do not make a difference in Kattis Kattis has it's own version of the game specific files. please use the provided skeleton and solve the problem there.

Question 3: I keep getting "Wrong Answer" but all is good in my local copy? Check if your answer format is correct. Kattis expects the answer in a defined way, make sure your code produces that. Check if you included debugging messages to the standard output. Kattis will interpret it as your answer! Use the error output or comment out the messages.