Artificial Intelligence in Algorithmic Trading: An Extended Guide

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Abstract

This document provides a template for reports in the ”AI in Financial Services” course, using EB Garamond for prose and Libertinus Math for formulas. It includes a cover page, abstract, table of contents, and sample sections for math and text. Additional content demonstrates tables, code, and references.

Keywords: artificial intelligence, algorithmic trading, quantitative finance, machine learning

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1 Record of Answers and Brief Explanations (Paradigms, Bets, Dutch Book)

1.1 Question 1

Question. If you randomly guess on a 4-option multiple choice question, you have probability 0.25 of being correct. Which probabilistic paradigm does this argument best demonstrate?

Answer.

Classical

Explanation. This uses the idea of *equally likely outcomes* (4 options, 1 correct), so

$$P(\text{correct}) = \frac{1}{4}.$$

That is the classical (Laplace) definition.

1.2 Question 2

Question. On a 3-option question, one option has a keyword the professor used often, so you assign it probability $> 1/3$ of being correct (based on your belief and extra information). Which paradigm?

Answer.

Bayesian

Explanation. You are using *subjective* beliefs updated by extra information (the keyword) rather than symmetry or long-run frequencies, which is Bayesian in spirit.

1.3 Question 3

Question. Empirically, one in three students participates in extracurricular activities, so you conclude

$$P(\text{random student participates}) = \frac{1}{3}.$$

Which paradigm?

Answer.

$$\text{Frequentist}$$

Explanation. This interprets probability as a *long-run relative frequency* in a population or repeated sampling.

1.4 Question 4 — Chess bet, $p = 1$

Question. Bet: if *she* wins, you pay her \$3; if *you* win, she pays you \$5. If she is 100% confident she will win, what is her expected return?

Answer.

$$3$$

Explanation. Let p be her personal probability of winning. For her,

$$\text{payoff} = \begin{cases} +3, & \text{she wins,} \\ -5, & \text{she loses.} \end{cases}$$

With $p = 1$,

$$\mathbb{E}[\text{payoff}] = 1 \cdot 3 + 0 \cdot (-5) = 3.$$

1.5 Question 5 — Chess bet, $p = 0.5$

Question. Same bet, but now her personal probability of winning is $p = 0.5$. What is her expected return?

Answer.

$$-1$$

Explanation.

$$\mathbb{E}[\text{payoff}] = p \cdot 3 + (1 - p) \cdot (-5) = 0.5 \cdot 3 + 0.5 \cdot (-5) = 1.5 - 2.5 = -1.$$

1.6 Question 6 — Fair bet ⇒ her p

Question. She will only accept the bet if it is *fair* for her, i.e. expected return = 0. Find her personal probability p of winning.

Answer.

$$p = \frac{5}{8}.$$

Explanation. As before,

$$\mathbb{E}[\text{payoff}] = 3p + (-5)(1-p) = 3p - 5 + 5p = 8p - 5.$$

Set this equal to 0 for a fair bet:

$$8p - 5 = 0 \implies p = \frac{5}{8}.$$

1.7 Question 7 — Dutch book payoff

Question. Two bets:

(i) If it rains or is overcast tomorrow, you pay him \$4; otherwise he pays you \$6.
(ii) If it is sunny tomorrow, you pay him \$5; otherwise he pays you \$5.

Events considered: rain, overcast, sunny (mutually exclusive and exhaustive). If you take *both* bets, how much do you win regardless of the outcome?

Answer.

$$1$$

Explanation. Let us compute your net payoff in each case.

Bet (i).

$$\text{rain/overcast: } -4, \quad \text{sunny: } +6.$$

Bet (ii).

$$\text{sunny: } -5, \quad \text{not sunny (rain/overcast): } +5.$$

Total payoff:

$$\begin{aligned} \text{Rain/overcast:} \quad & -4+5=+1, \\ \text{Sunny:} \quad & +6-5=+1. \end{aligned}$$

So you win \$1 no matter what happens.

1.8 Question 8 — Incoherent probabilities

Question. For bet (i) to be fair, his probability that it rains or is overcast must be 0.6. For bet (ii) to be fair, his probability that it is sunny must be 0.5.

These events are exhaustive and disjoint, but his "probabilities" do not sum to 1. What do they sum to?

Answer.

$$0.6+0.5=1.1.$$

Explanation. Let A = "rain or overcast" and B = "sunny." He is using

$$P(A)=0.6, \quad P(B)=0.5,$$

with A and B disjoint and exhaustive. Coherent probabilities should satisfy

$$P(A)+P(B)=1,$$

but instead

$$P(A)+P(B)=0.6+0.5=1.1>1,$$

which is impossible, and this incoherence enables the Dutch book.