第一套题目：2020/21学年

考试信息

- **模块代码**: COMP0137
- **模块名称**: Machine Vision
- **考试日期**: 2021年5月11日 10:00
- **持续时间**: 24小时
- **适用学年**: 2020/21
- **级别**: 本科（硕士级别）/研究生
- **说明**: 考生需回答所有问题，总分100分，答案需通过Moodle在线提交，除非特别说明，无需展示计算过程。

Section A: A Graphical Model

Question 1
This section involves a Markov Model with five discrete variables X_1 to X_5, each with specific states. A "configuration" is a combination of states assigned to each variable. Use the unary, pairwise, and triplet cost tables below to answer the questions.

Unary Costs

Variable	State	Cost
X_1	A	2
X_1	B	3
X_2	C	1
X_2	D	4
X_2	E	2
X_3	F	5
X_3	G	3
X_3	H	2
X_4	I	4
X_4	J	1
X_4	K	3
X_5	L	2
X_5	M	5
X_5	N	3

Pairwise and Triplet Costs

Combination	States	Cost
X_1, X_2	A, C	1
X_1, X_2	A, D	2
X_1, X_2	A, E	3
X_1, X_2	B, C	4
X_1, X_2	B, D	5
X_1, X_2	B, E	6
X_2, X_3	C, F	2
X_2, X_3	C, G	3
X_2, X_3	C, H	4
X_2, X_3	D, F	5
X_2, X_3	D, G	6
X_2, X_3	D, H	7
X_2, X_3	E, F	8
X_2, X_3	E, G	9
X_2, X_3	E, H	10
X_3, X_4	F, I	3
X_3, X_4	F, J	4
X_3, X_4	F, K	5
X_3, X_4	G, I	6
X_3, X_4	G, J	7
X_3, X_4	G, K	8
X_3, X_4	H, I	9
X_3, X_4	H, J	10
X_3, X_4	H, K	11
X_4, X_5	I, L	4
X_4, X_5	I, M	5
X_4, X_5	I, N	6
X_4, X_5	J, L	7

Combination	States	Cost
X_4, X_5	J, M	8
X_4, X_5	J, N	9
X_4, X_5	K, L	10
X_4, X_5	K, M	11
X_4, X_5	K, N	12
X_1, X_3, X_5	A, F, L	5
X_1, X_3, X_5	A, G, M	6
X_1, X_3, X_5	B, H, N	7

Questions:
(a) Configuration A is ACGJN. Compute the total cost of this configuration: _
[7 marks]

(b) Configuration B is AEFKM. Compute the total cost of this configuration: _
[7 marks]

(c) What is the Maximum Likelihood configuration? _ _ _ _ _
[7 marks]

(d) What is the Maximum a Posteriori configuration? _ _ _ _ _
[8 marks]

[Total for Question 1: 29 marks]

Section B: Solar Energy Task

Question 2
Your company develops solar-energy farms in the UK, evaluating empty fields for flat solar panel installation. You must predict a field's energy yield before construction, considering business, weather, and environmental factors. While post-installation power generation is easily measured, prospective installation is impractical. Instead, a wide-field-of-view dome camera captures sky images over time. Using data from three or four existing farms (energy yield and dome-camera photos), you'll train a computer vision model to predict energy yield.

Questions:
(a) Even without energy-yield data, you can train an auto-encoder with dome-camera images. Name one benefit of this approach.
Answer: ___
[6 marks]

(b) You collect paired data (energy yield and images) monthly. Why might relying solely on January data be unwise?
Answer: ____
[6 marks]

(c) When might training the model in the dual domain be preferable for energy yield prediction?
Answer: _____
[6 marks]

(d) Describe one scenario where the difference between a Maximum A Posteriori (MAP) and a Bayesian model matters.
Answer: _____
[6 marks]

(e) Sites with dome cameras are geographically scattered, not grid-like. How does this affect pairwise potentials in a Markov Random Field for energy-yield regularization?
Answer: _____
[6 marks]

[Total for Question 2: 30 marks]

Section C: Miscellaneous Questions

Question 3
Consider probability distributions where the second is not conjugate to the first. In one sentence each, describe:
a) One potential benefit of using non-conjugate distributions.
b) One potential disadvantage.

[6 marks]

Question 4
You need to determine a crash-test dummy's pose from a single, unoccluded image. A limb-detector provides an unordered list of bounding boxes for limbs (e.g., chest, left upper arm).

(a) In at most two sentences, explain how to obtain training data for pairwise terms in a tree-model to find the Maximum A Posteriori limb-label configuration.

[6 marks]

(b) Now, labels include 3D position and orientation. In two sentences, explain why dynamic programming might be regrettable for the MAP solution. Add a third sentence naming an alternative and its trade-off.

[6 marks]

[Total for Question 4: 12 marks]

Question 5
Research "Event Camera" (e.g., via Wikipedia). For each scenario, choose: a) Regular CMOS camera, b) Event camera, or c) Both equally effective.
5.a: Detect an animal sneaking in a garden at night. __
5.b: Generate a deblurred color wedding photo. __

5.c: Feed a face recognition system for keyless entry. __
5.d: Inspect train tracks from a moving train. __
5.e: Detect forgery in paper banknotes. __
[12 marks]

Question 6
Give two distinct reasons why parallel lines in the real world appear non-parallel in a photograph.

[4 marks]

Question 7
To buy roof tiles, you compute a dense 3D point cloud from a color image sequence of a house and segment the roof points. In one sentence, describe the critical step to compute the roof's surface area.

[4 marks]

[Total for Questions 3-7: 41 marks]
[Total for all questions: 100 marks]

2020/21学年机器视觉考试答案

Section A: A Graphical Model

题目1

(a) 配置 A (ACGJN) 的总代价

- **单目代价**:
  - X1=A: 2
  - X2=C: 1
  - X3=G: 3
  - X4=J: 1
  - X5=N: 3
  - 总和 = 2 + 1 + 3 + 1 + 3 = 10
- **双目代价**:
  - X1=A, X2=C: 1
  - X2=C, X3=G: 3
  - X3=G, X4=J: 7
  - X4=J, X5=N: 9
  - 总和 = 1 + 3 + 7 + 9 = 20
- **三元组代价**:
  - X1=A, X3=G, X5=N 未在表中，假设为 0
- **总代价** = 10 + 20 + 0 = **30**

答案：30

(b) 配置 B (AEFKM) 的总代价

- **单目代价**:
  - X1=A: 2
  - X2=E: 2
  - X3=F: 5
  - X4=K: 3
  - X5=M: 5
  - 总和 = 2 + 2 + 5 + 3 + 5 = 17
- **双目代价**:
  - X1=A, X2=E: 3
  - X2=E, X3=F: 8
  - X3=F, X4=K: 5
  - X4=K, X5=M: 11
  - 总和 = 3 + 8 + 5 + 11 = 27
- **三元组代价**:
  - X1=A, X3=F, X5=M 未在表中，假设为 0
- **总代价** = 17 + 27 + 0 = **44**

答案：44

(c) 最大似然配置

最大似然配置对应于总代价最小的配置。经过枚举和优化，最优配置为 **A C G I L**:

- **单目代价**:
  - X1=A: 2
  - X2=C: 1
  - X3=G: 3
  - X4=I: 4
  - X5=L: 2
  - 总和 = 2 + 1 + 3 + 4 + 2 = 12
- **双目代价**:
  - X1=A, X2=C: 1
  - X2=C, X3=G: 3
  - X3=G, X4=I: 6
  - X4=I, X5=L: 4
  - 总和 = 1 + 3 + 6 + 4 = 14
- **三元组代价**:
  - X1=A, X3=G, X5=L 未在表中，假设为 0
- **总代价** = 12 + 14 + 0 = **26**

答案：A C G I L

(d) 最大后验配置

在无额外先验信息的情况下，最大后验配置与最大似然配置相同。

答案：A C G I L

Section B: Solar Energy Task

题目2

(a) 训练自编码器的好处

自编码器通过无监督学习提取图像特征或降低维度，提升后续预测性能。

答案: Unsupervised feature learning or dimensionality reduction.

(b) 仅使用一月数据不明智的原因

一月数据无法反映全年天气和太阳能产出的季节性变化。

答案: Seasonal variation in weather and solar energy yield.

(c) 双域训练更可取的情况

当图像和能量数据在不同域（如频域）中具有更强的相关性时。

答案: When cross-domain features improve prediction accuracy.

(d) MAP和贝叶斯模型差异重要的场景

当需要量化不确定性时，如数据稀缺或安全关键应用。

答案: When uncertainty quantification is crucial, such as in safety-critical applications.

(e) 非网格状场地对MRF成对势能的影响

成对势能需根据实际空间关系而非固定网格定义。

答案: Pairwise potentials must account for irregular spatial relationships.

Section C: Miscellaneous Questions

题目3

(a) 非共轭分布的好处

提供更大的建模灵活性。

答案: Greater modeling flexibility.

(b) 缺点

增加计算复杂度。

答案: Increased computational complexity.

题目4

(a) 获取训练数据的方法

手动标注肢体对应关系，或使用已有标签数据集。

答案: Collect labeled data with limb correspondences or use synthetic data with known labels.

(b) 动态规划的缺点及替代方法

缺点：高维状态空间计算不可行。替代：采样或近似推断。

答案: High-dimensional state space makes computation infeasible; alternatives like sampling sacrifice accuracy.

题目5

(a-e) 选择适合的相机

- 5.a: **b) Event camera** (低光运动检测)
- 5.b: **a) CMOS camera** (颜色和细节)
- 5.c: **a) CMOS camera** (面部特征细节)
- 5.d: **b) Event camera** (高速运动)
- 5.e: **a) CMOS camera** (纹理和颜色细节)

题目6

图像畸变原因

- 原因1：透视投影
- 原因2：镜头畸变

答案: Perspective projection and lens distortion.

题目7

关键步骤

从点云生成屋顶三角网格并计算面积。

答案: Generate a mesh from the point cloud and compute its surface area.