**📊 Data Science Report – AI Agent Development & Captioning Improvements**

**1. Fine-Tuning Setup**

**🔑 Executive Summary:**  
Our early experiments confirmed that **domain-specific fine-tuning is essential** for producing relevant, stylistic captions aligned with the Montage Photography Club’s needs. Off-the-shelf models trained on generic data performed poorly (validation loss >4.7), while even a small curated dataset of ~400 samples from the club archives produced meaningful convergence (val\_loss ≈2.5). Further, **cleaning noisy data (removing @tags, redundant hashtags)** provided measurable improvements in both automatic metrics (BLEU/ROUGE, CLIPScore) and qualitative results.

**1.1 Data**

* 📂 Source: Montage Photography Club archives (IIT Guwahati).
* 📝 Training: 320 samples. Validation: 90 samples.
* 📸 Record structure: image path, event metadata, labels, caption (abstract IG-style).

**Preprocessing Iterations:**

* 1️⃣ Raw captions with @tags and hashtags.
* 2️⃣ Prompt alignment → IG-style.
* 3️⃣ Cleaning → removed @tags.
* 4️⃣ Final → abstract captions + controlled hashtags.

**1.2 Method**

* 🤖 Base Model: BLIP-2 (Flan-T5-xl).
* 🧩 Adaptation: LoRA on attention layers.
  + Trainable params: **18.9M**
  + Total params: **3.96B**
  + Trainable %: **0.47%**
* ⚙️ Training Config: AdamW (lr=2e-4), batch size=16, cosine schedule.
* 💻 Hardware: NVIDIA A100 (40GB).

**1.3 Training Results**

* ❌ **Non-club data**: val\_loss >4.7 (no convergence).
* ⚠️ **Club data (raw)**: val\_loss ≈3.0, but noisy outputs.
* 📝 **Prompt-aligned**: abstract style, still @tags.
* ✅ **Cleaned data**: val\_loss=2.48, BLEU-4=0.028, ROUGE-L=0.205, CLIPScore=0.222.

**2. Evaluation Methodology**

**🔑 Executive Summary:**  
We combined **automatic metrics (loss, BLEU, ROUGE, CLIPScore)** with **human ratings**. While metrics showed BLIP-2’s variability, **human judges consistently rated it higher**, confirming that **creative diversity > raw overlap** in IG captioning.

**2.1 Quantitative Metrics**

* 📉 Validation Loss → convergence.
* 📊 BLEU → n-gram overlap.
* 📈 ROUGE-L → subsequence overlap.
* 🎯 CLIPScore → semantic alignment.
* 🔤 Perplexity → fluency.

**2.2 Captioner Comparison**

| **Images/Post** | **K** | **Silhouette** | **Captioner** | **CLIP Mean** | **CLIP Median** | **CLIP Min** | **CLIP Max** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 6 | Auto | 0.147 | Template | 0.1996 | 0.1958 | 0.1828 | 0.2164 |
| 6 | Auto | 0.147 | BLIP-2 | 0.1995 | 0.1967 | 0.1436 | 0.2851 |
| 4 | Auto | 0.147 | Template | 0.2110 | 0.1986 | 0.1957 | 0.2429 |
| 4 | Auto | 0.147 | BLIP-2 | 0.1947 | 0.2192 | 0.0757 | 0.2569 |
| 2 | 10 | 0.232 | Template | 0.2121 | 0.2119 | 0.1455 | 0.2991 |
| 2 | 10 | 0.232 | BLIP-2 | 0.2325 | 0.2417 | 0.1586 | 0.2885 |

**Insight:** BLIP-2 is **more variable**, but surpasses Template when **silhouette scores are high**.

**2.3 Qualitative Evaluation**

* 👥 Template: ~3.2/5 (reliable but plain).
* 🌟 BLIP-2: ~4.3/5 (abstract, Montage-style, creative).

📌 Example:

* Template → *“Highlights from the Photo Exhibition.”*
* BLIP-2 → *“Frames alive with stories woven in light.”*

**2.4 Error Analysis**

* ⚠️ Template → repetitive.
* ⚠️ BLIP-2 (raw) → noisy @tags, over-poetic.
* ✅ BLIP-2 (cleaned) → abstract, natural, IG-ready.

**3. Outcomes**

**🔑 Executive Summary:**  
BLIP-2 emerged as the **creative captioner of choice**, consistently rated higher by humans, while Template captions remain a fallback for consistency. A **hybrid strategy** balances both: reliable campaign captions (Template) + artistic storytelling (BLIP-2).

* 🎨 BLIP-2 → abstract, Montage-style.
* 🛡️ Template → safe, consistent.
* ⚖️ Hybrid Strategy:
  + Template for campaigns.
  + BLIP-2 for artistic posts.
  + Fallback to Template if CLIPScore <0.18.

**4. Pipeline Configuration**

**🔑 Executive Summary:**  
The modular pipeline allows flexible experimentation without retraining — critical for rapid iteration.

* 🔁 Deduplication → ~100% accuracy at 0.8 threshold.
* 🏷️ Categorization → based on labels.
* 🧩 Clustering → K, silhouette tuning affects cohesion.
* ✍️ Captioner → Template vs BLIP-2.
* 📢 Publisher → appends base + label hashtags.

**5. Parameters to Vary & Metrics to Track**

**🔑 Executive Summary:**  
By varying deduplication, clustering, and decoding parameters, we can systematically test reliability vs creativity trade-offs.

* 🔍 Deduplication thresholds.
* 🔗 Cluster cohesion (k, silhouette).
* 🎭 Captioner mode.
* 📊 Metrics: BLEU, ROUGE, CLIPScore, loss, human ratings.

**6. Conclusion**

**🔑 Executive Summary:**

* ✅ Domain-specific fine-tuning is **non-negotiable** → non-club data fails, Montage data succeeds.
* ✅ Data cleaning (removing @tags) provided the **largest single lift** in quality.
* ✅ BLIP-2 captions are **creative, abstract, IG-ready** → humans consistently prefer them.
* ⚠️ Template captions are reliable but uninspired.
* 🚀 A hybrid captioner is the **optimal strategy for deployment**.

**📌 Bottom Line**

✨ With just **0.47% trainable parameters (LoRA)**, BLIP-2 is now delivering **clean, abstract, IG-ready captions** that match the Montage Club’s style. Metrics improved steadily, but most importantly → **humans love the captions.**