Image Search:

1. Users upload an image to Etsy’s search bar
2. CNNs are used to gather information from the image
3. Pull Images from Etsy’s data warehouses that are related to this image
4. Provide multiple image results of matching products on Etsy
5. Results can match directly to the uploaded image or be on similar category (e.g. an uploaded image of a cat can bring results for animal products)

### **1. Image Upload and Ingestion:**

* **User Upload**: A user uploads an image to Etsy’s search bar.
* **Preprocessing**: Before sending the image to a neural network, it needs to be preprocessed. This may involve:
  + Resizing the image to a standard size expected by the CNN (e.g., 224x224 pixels for common CNN architectures like ResNet).
  + Normalizing pixel values to make them suitable for the neural network model.
  + Possibly converting the image to grayscale or another color format if necessary for the specific model.

**Ingestion Architecture**:

* **Frontend (Web/App)**: The user’s image is uploaded through Etsy’s web or mobile app.
* **Image Storage**: Store the image temporarily in a **cloud storage** service (e.g., AWS S3, Google Cloud Storage).
* **Metadata Extraction**: Extract image metadata (file size, format) and store it for logging or tracking purposes.

### **2. CNN-based Feature Extraction:**

* **CNN Model**: Use a **Convolutional Neural Network (CNN)** to extract features from the uploaded image. Commonly used architectures include **ResNet**, **Inception**, or **VGG**. The CNN will:
  + Pass the image through multiple convolutional layers to identify low-level features (e.g., edges, shapes) and high-level features (e.g., objects, categories).
  + Output a feature vector or embedding that represents the key characteristics of the image.

**Model Selection**:

* **Pre-trained Models**: Use pre-trained models on large image datasets (e.g., ImageNet) to save time and resources.
* **Fine-tuning**: Fine-tune the CNN on Etsy-specific product images to improve performance for relevant categories.

### **3. Similarity Search (Image-to-Image Matching):**

* **Feature Embedding Matching**:
  + Take the feature vector of the uploaded image and compare it to the feature vectors of Etsy’s product images. This is typically done by calculating the **cosine similarity** or **Euclidean distance** between the feature vectors.
  + The most similar images (those with the smallest distance or highest cosine similarity) are considered the best matches.
* **Indexed Database for Image Embeddings**:
  + Store all Etsy product images’ embeddings (generated by the CNN) in an indexed search database like **Faiss (Facebook AI Similarity Search)**, **Annoy (Approximate Nearest Neighbors)**, or **Elasticsearch**.
  + These tools allow efficient similarity searching over large datasets.

### **4. Image Metadata Matching (Category-Based Search):**

* **Category Matching Logic**:
  + If the direct matches (via embeddings) are insufficient, the system can provide results based on the image category. For instance, an image of a cat might lead to recommendations from the "Pet Products" category.
  + Use **CNN classifiers** or image tags (metadata) to predict the product category based on the uploaded image. The classifier can output category probabilities that allow Etsy to expand the search scope.
* **Etsy’s Product Metadata**:
  + Etsy’s product data warehouse should store rich metadata, such as **product categories**, tags (e.g., "animal", "handmade", etc.), price, seller information, and product images. This information can be used to expand or refine the search.

### **5. Data Retrieval from Etsy’s Data Warehouse:**

* **Query Matching Images**:
  + Query the data warehouse using the embeddings from the similarity search. This may involve querying both the image embeddings index and product metadata (such as categories and tags).
* **Search on Multiple Factors**:
  + Rank the results based on **multiple factors** such as:
    - Cosine similarity or distance score between image embeddings.
    - Relevance of the product category or tags to the uploaded image (e.g., if an animal is detected, give higher weight to “Pet Products”).
    - Popularity of the product (e.g., based on ratings, purchases).
    - Seller preferences or personalized user recommendations.

### **6. Post-processing and Filtering:**

* **Filter Results**:
  + Filter out inappropriate or irrelevant images, possibly using **content filtering** models.
  + Sort results by relevance, popularity, or price, depending on the user’s search context.
  + Allow users to refine the search (e.g., filtering by price range, category, or location).
* **Diversity in Results**: Provide diverse results by ensuring that different categories and styles of products appear in the results (this avoids showing many similar items).

### **7. Search Results Delivery:**

* **Front-End Display**:
  + Present the search results to the user through a responsive UI, showing multiple product images.
  + Include metadata with each result, such as price, product name, seller rating, and tags.
* **Personalized Ranking**: Incorporate personalized ranking based on the user’s preferences, browsing history, or purchase history (if available).

### **8. Feedback Loop:**

* **User Interaction Data**:
  + Track user interactions with the search results, such as clicks, purchases, or saved items.
  + Use this data to improve future recommendations and search performance.
* **Retraining Models**: Regularly retrain the CNN models and classifiers with new product data and user interaction feedback.

### **Detailed Pipeline Flow:**

1. **Image Upload & Preprocessing**:
   * User uploads an image → image is preprocessed (resizing, normalizing) and stored temporarily.
2. **CNN Feature Extraction**:
   * The image is passed through a CNN to extract a feature vector/embedding representing the image.
3. **Similarity Search**:
   * The feature vector is compared with precomputed embeddings of Etsy product images using a similarity search (Faiss, Elasticsearch).
   * The closest matches are identified based on cosine similarity or Euclidean distance.
4. **Category-Based Search (Fallback)**:
   * If direct matches are insufficient, a classifier predicts the image category (e.g., "Pet Products" for an image of a cat).
   * The search is expanded to include similar product categories.
5. **Data Retrieval from Data Warehouse**:
   * Query Etsy’s product database for images matching either the embeddings or the predicted category.
   * Retrieve additional product details (name, price, category, etc.).
6. **Post-Processing**:
   * Filter, sort, and rank the results based on relevance, popularity, or personalization.
   * Ensure diversity in the results (not just visually similar items but a range of relevant products).
7. **Results Delivery**:
   * Display the matching products with corresponding images and metadata on the user interface.
   * Allow users to interact with the results (click, purchase, refine search).
8. **Feedback Loop**:
   * Capture user interactions with the search results (e.g., clicks, purchases) to continually improve recommendations.
   * Periodically retrain models with new product and interaction data.

Incorporating Social Media into our solution: