Voyage AI Integration for Trainable Chatbot

This document describes the comprehensive Voyage AI integration implemented in the trainable chatbot project, following a phased approach as requested.

Overview

The integration provides a complete AI embedding management system with support for both Voyage AI and OpenAI models, tenant-specific configurations, batch processing, and comprehensive analytics.

Phase 1: Basic Voyage AI Integration ✅

Features Implemented:

- **Voyage AI SDK Integration**: Direct API integration using fetch for reliable performance
- **Multi-Model Support**: Support for Voyage AI and OpenAI embedding models
- **Embedding Service**: Centralized service for generating embeddings with model abstraction
- **Database Schema**: Extended schema with embedding settings and job tracking tables
- **Vector Storage**: Enhanced knowledge base with embedding storage in Supabase

Available Models:

1. **Voyage AI Models:**
   - `voyage-large-2-instruct` : Best for instruction-following and complex reasoning tasks (1536D)
   - `voyage-large-2` : High-performance general-purpose embedding model (1536D)
   - `voyage-code-2` : Specialized for code understanding and similarity (1536D)

2. **OpenAI Models:**
   - `text-embedding-3-small` : Cost-effective OpenAI embedding model (1536D)
   - `text-embedding-3-large` : High-performance OpenAI embedding model (3072D)

API Endpoints:

- `POST /api/embeddings` - Generate embeddings for text input
- `GET /api/embeddings` - Get available embedding models

Phase 2: Settings Panel ✅

Admin Settings Dashboard:

- **Comprehensive UI**: Modern, responsive interface with real-time updates
- **Model Configuration**: Easy setup and management of embedding models per tenant
- **Default Model Selection**: Set preferred models for automatic processing
- **Model Testing**: Built-in functionality to test model performance
- **Real-time Preview**: Immediate feedback on configuration changes

Features:

- **Model Cards**: Visual representation of each configured model with key metrics
- **Status Indicators**: Clear visual feedback on model status and performance

- **Configuration Management**: Add, edit, and remove model configurations
- **Tenant Isolation**: Proper multi-tenant model configuration support

API Endpoints:

- `GET /api/admin/embedding-settings` - Get tenant embedding configurations
- `POST /api/admin/embedding-settings` - Create new model configuration
- `PUT /api/admin/embedding-settings/[id]` - Update existing configuration
- `DELETE /api/admin/embedding-settings/[id]` - Remove configuration
- `POST /api/admin/embedding-settings/initialize` - Initialize default models

Phase 3: Enhanced Features ✅

Batch Processing:

- **Bulk Operations**: Process all knowledge base entries with selected model
- **Model Migration**: Seamlessly migrate between different embedding models
- **Progress Tracking**: Real-time progress monitoring with job management
- **Background Processing**: Non-blocking operations with status updates

Performance Analytics:

- **Processing Statistics**: Comprehensive metrics on embedding generation
- **Model Distribution**: Visual breakdown of model usage across entries
- **Completion Tracking**: Progress monitoring for batch operations
- **Job History**: Complete history of processing jobs with status details

Advanced Features:

- **Automatic Embedding Generation**: New knowledge base entries auto-generate embeddings
- **Smart Re-processing**: Only process entries that need updates
- **Error Handling**: Comprehensive error handling with fallback mechanisms
- **Vector Similarity Search**: Enhanced search with semantic similarity (ready for pgvector)

API Endpoints:

- `POST /api/admin/batch-processing` - Trigger batch processing operations
- `GET /api/admin/embedding-jobs` - Get processing job status and history

Technical Implementation

Architecture Components:

1. **EmbeddingService** (`lib/services/embedding-service.ts`)
   - Centralized embedding generation
   - Multi-provider support (Voyage AI, OpenAI)
   - Error handling and fallback mechanisms

2. **Database Services**:
   - **embedding-settings.ts**: Tenant-specific model configurations
   - **embedding-jobs.ts**: Background job management
   - **knowledge-base.ts**: Enhanced with embedding integration

3. **Batch Processing** (`lib/services/batch-processing-service.ts`)
   - Background processing with progress tracking
   - Model migration utilities
   - Performance analytics

4. **UI Components**:
   - **EmbeddingSettingsPanel**: Main configuration interface
   - **EmbeddingModelCard**: Individual model management
   - **EmbeddingAnalyticsDashboard**: Performance monitoring

Database Schema Extensions:

```
-- Tenant-specific embedding configurations
CREATE TABLE tenant_embedding_settings (
  id UUID PRIMARY KEY,
  tenant_id UUID REFERENCES tenants(id),
  model_id TEXT NOT NULL,
  model_name TEXT NOT NULL,
  provider TEXT NOT NULL,
  dimensions INTEGER NOT NULL,
  is_default BOOLEAN DEFAULT false,
  settings JSONB,
  created_at TIMESTAMP WITH TIME ZONE DEFAULT NOW(),
  updated_at TIMESTAMP WITH TIME ZONE DEFAULT NOW()
);

-- Background job tracking
CREATE TABLE embedding_jobs (
  id UUID PRIMARY KEY,
  tenant_id UUID REFERENCES tenants(id),
  model_id TEXT NOT NULL,
  status TEXT DEFAULT 'pending',
  progress INTEGER DEFAULT 0,
  total_items INTEGER DEFAULT 0,
  processed_items INTEGER DEFAULT 0,
  error_message TEXT,
  metadata JSONB,
  created_at TIMESTAMP WITH TIME ZONE DEFAULT NOW(),
  updated_at TIMESTAMP WITH TIME ZONE DEFAULT NOW()
);
```

Environment Setup

Required Environment Variables:

```
# Existing
ABACUSAI_API_KEY="your_abacus_ai_api_key"

# New for Voyage AI
VOYAGE_API_KEY="your_voyage_ai_api_key"

# Supabase (existing)
NEXT_PUBLIC_SUPABASE_URL="your_supabase_url"
NEXT_PUBLIC_SUPABASE_ANON_KEY="your_supabase_anon_key"
```

Usage Guide

1. Access Admin Settings:

Navigate to `/admin/settings` to access the AI model management interface.

2. Configure Models:

- View available embedding models
- Add model configurations for your tenant
- Set default models for automatic processing
- Test model functionality

3. Monitor Performance:

Switch to the “Analytics & Processing” tab to:
- View processing statistics
- Monitor batch job progress
- Analyze model distribution
- Track completion rates

4. Batch Operations:

- Process all knowledge base entries with embeddings
- Migrate between different models
- Monitor progress in real-time

Integration with Existing System

Knowledge Base Enhancement:

- Automatic embedding generation for new entries
- Enhanced search capabilities with vector similarity
- Model-aware processing with metadata tracking

Multi-Tenant Support:

- Tenant-specific model configurations
- Isolated processing environments
- Per-tenant analytics and monitoring

Streaming API Compatibility:

- Maintains existing streaming chat functionality
- Enhanced with knowledge base semantic search
- Backward compatible with existing chat sessions

Future Enhancements

Planned Improvements:

1. **pgvector Integration**: Full vector similarity search with PostgreSQL
2. **Advanced Analytics**: Model performance comparisons and recommendations
3. **Custom Model Training**: Support for fine-tuned embedding models
4. **API Rate Limiting**: Smart rate limiting for embedding generation

5. **Caching Layer**: Redis-based embedding cache for performance

Scalability Considerations:

- Background job processing with queue system
- Horizontal scaling for embedding generation
- Database optimization for vector operations
- CDN integration for model artifacts

Testing the Integration

Manual Testing:

1. Navigate to `/admin/settings`
2. Initialize default models
3. Add a new model configuration
4. Test model functionality
5. Process existing knowledge base entries
6. Monitor progress in analytics dashboard

API Testing:

```
# Test embedding generation
curl -X POST http://localhost:3000/api/embeddings \
  -H "Content-Type: application/json" \
  -d '{"text": "Test embedding generation", "model": "voyage-large-2-instruct"}'

# Get available models
curl http://localhost:3000/api/embeddings
```

Support and Troubleshooting

Common Issues:

1. **Missing API Keys**: Ensure VOYAGE_API_KEY is set
2. **Database Migrations**: Run migrations for new tables
3. **Model Initialization**: Use the initialize endpoint for default models
4. **Rate Limiting**: Handle API rate limits gracefully

Monitoring:

- Check embedding job status in admin panel
- Monitor API response times
- Review error logs for failed processing
- Track completion rates and model performance

Implementation Status: ✅ Complete
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