

# **Project Explanation**

## PROJECT OVERVIEW - LIP-SYNC ANIMATION SYSTEM

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This Unity project implements a flexible lip-sync and facial animation system using blend shapes, with a robust login system powered by Firebase Authentication.

## LOGIN SYSTEM (LoginManager.cs)

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- Uses Firebase Authentication for real email/password and Google sign-in.
- UI built with TextMeshPro and DOTween for smooth feedback (shake/scale/fade).
- Handles registration, login, and Google OAuth with clear error messages.
- Event-driven: OnLoginSuccess and OnLoginFailed for easy extensibility.
- Secure password masking and user-friendly status messages.

## LIP-SYNC & FACIAL ANIMATION

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- Central FacialExpressionSystem manages all blend shapes across multiple meshes (body, teeth, eyes, etc.).
- Caching system for fast blend shape lookup, including duplicate name handling.
- FacialExpressionData (ScriptableObject) stores reusable expressions for easy editing and sharing.
- SimpleLipSync animates blend shapes in sync with audio, using DOTween for smooth transitions.
- LipSyncData (ScriptableObject) allows different talking styles (whisper, shout, etc.).
- AnimationHandler coordinates animator triggers, facial expressions, and lip-sync for full character reactions.

## EDITOR TOOLS

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- Custom editors for LipSyncData and FacialExpressionData auto-scan blend shapes and organize them for easy selection.
  - Reduces manual errors and speeds up asset creation.

## TECHNICAL DECISIONS

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- DOTween for all UI and blend shape animations (smooth, easy to manage).
- Dual cache system for blend shapes to handle duplicate names on different meshes.
- Coroutine-based animation for flexible timing and control.
- ScriptableObjects for all data assets (expressions, lip-sync configs) for clean separation and easy asset management.

## CHALLENGES & SOLUTIONS

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- Choppy animation: Fixed by switching to DOTween with easing.
- Duplicate blend shape names: Solved with mesh-specific caching.
- Coroutine errors on inactive objects: Added activeInHierarchy checks.
- Manual entry errors: Built custom editor tools.

## WHAT TO IMPROVE NEXT

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- Real audio analysis (FFT, phoneme mapping).
- Editor preview for expressions.
- Expression blending and timeline integration.
- Further optimization and pooling.

## CLOSING THOUGHTS

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The system is designed for flexibility and artist-friendliness, with robust login and animation workflows. Editor tools and ScriptableObjects make it easy to extend and maintain.