Phase 2 Features - 360° Visualization Tab

Overview

Phase 2 implements advanced AI-powered features for the 360° Visualization tab, addressing all previous limitations and adding professional-grade capabilities.

☑ Implemented Features

1. AI-Powered Surface Detection 🤖

File: `src/features/visualization360/services/AISurfaceDetection.js`

Capabilities:

- Automatic roof surface detection using TensorFlow.js
- Wall and edge detection for complete property analysis
- Fallback heuristic detection when AI model unavailable
- Confidence scoring for each detected surface
- Suitable product recommendations per surface type

Usage:

```
import { surfaceDetector } from './services/AISurfaceDetection';

// Initialize AI model (optional - will fallback if unavailable)
await surfaceDetector.initialize();

// Detect surfaces in image
const result = await surfaceDetector.detectSurfaces(imageUrl);
// Returns: { surfaces, confidence, method: 'ai' | 'heuristic' }
```

Features:

- DeepLab-style segmentation model support
- Color and geometry-based heuristic detection
- Surface classification: roof, wall, eave, edge
- Bounding box and area calculations
- Product placement recommendations

---

2. Automatic Product Placement 🎯

File: `src/features/visualization360/services/AutoPlacement.js`

Capabilities:

- AI-driven automatic placement of shingles on detected roof surfaces
- Smart spacing and positioning of Rime lighting fixtures
- Ridge vent, gutter, and flashing auto-placement
- Optimization algorithms to prevent overlaps
- 2D to 3D coordinate conversion for panoramic sphere

Usage:

```
import { autoPlacement } from './services/AutoPlacement';

const result = await autoPlacement.autoPlaceAll(imageUrl, {
  shingleColor: 'weathered-wood',
  lightingPattern: 'uniform'
});

// Apply to visualization
result.placements.shingles.forEach(p => addShingleRegion(p));
result.placements.lighting.forEach(l => addLight(l));
```

Features:

- Automatic shingle coverage calculation with waste factor
- Intelligent lighting fixture spacing (12" standard)
- Edge and corner shingle detail placement
- Manual adjustment capability for all auto-placed products
- Summary statistics (coverage area, fixture count, etc.)

---

3. 3D Mesh Reconstruction from Photos 📸

File: `src/features/visualization360/services/Photogrammetry.js`

Capabilities:

- 8-photo capture workflow for complete house coverage
- Server-side photogrammetry processing
- Client-side point cloud preview generation
- Feature matching and triangulation
- 3D model export in GLB/OBJ formats

Required Photos:

1. Front Left Corner
2. Front Right Corner
3. Left Side Elevation
4. Right Side Elevation
5. Back Left Corner
6. Back Right Corner
7. Overhead/Drone View
8. Roof Detail Close-up

Usage:

```
import { photogrammetry } from './services/Photogrammetry';

// Process photos (requires server API)
const job = await photogrammetry.processPhotos(photoArray);

// Poll for status
const status = await photogrammetry.getStatus(job.jobId);

// Download 3D model
const model = await photogrammetry.downloadModel(job.jobId, 'glb');
```

Features:

- Photo quality validation (resolution, aspect ratio)
- GPS and orientation metadata capture
- Simplified client-side preview (feature detection & matching)
- Full server-side reconstruction pipeline
- Roof measurement extraction from 3D model

---

4. Advanced Measurement Tools

File: `src/features/visualization360/components/Tools/MeasurementTools.jsx`

Capabilities:

- Interactive distance measurement
- Surface area calculation (polygon-based)
- Roof pitch calculation (rise/run ratio + angle)
- Perimeter measurement
- Unit conversion (feet, meters, inches)
- Export measurements to CSV

Tools:

- **Distance Tool:** Click two points to measure linear distance
- **Area Tool:** Click points to define polygon area
- **Pitch Tool:** Measure roof slope (ratio and degrees)
- **Perimeter Tool:** Measure around surfaces

Features:

- Real-time measurement display
- Calibration for accurate real-world measurements
- Saved measurements library
- Summary statistics
- Integration with global measurements state

---

5. PDF Report Generation

File: `src/features/visualization360/services/PDFReportGenerator.js`

Capabilities:

- Professional multi-page PDF reports
- Before/after visualization comparisons
- Measurements and specifications
- Product details and descriptions
- Complete cost estimates with breakdowns
- Branded company information

Report Sections:

1. **Cover Page:** Project title, customer info, date
2. **Project Overview:** Details, description, timeline
3. **Visual Comparison:** Before/after images with improvements
4. **Measurements:** Roof area, pitch, perimeter, specifications
5. **Product Details:** Malarkey shingles, Rime lighting, accessories
6. **Cost Estimate:** Itemized breakdown, totals, payment terms

Usage:

```
import { pdfReportGenerator } from './services/PDFReportGenerator';

await pdfReportGenerator.save(projectData, 'project-report.pdf');

// Or get as blob for upload
const blob = await pdfReportGenerator.getBlob(projectData);
```

Features:

- Professional layout using jsPDF
- Automatic page formatting and pagination
- Image capture from 3D viewer
- Tables for measurements and costs
- Customizable branding and styling

---

6. Cost Estimation Calculator 💰

File: `src/features/visualization360/services/CostEstimator.js`

Capabilities:

- Comprehensive material cost calculations
- Labor cost estimation
- Waste factor adjustments
- Tax calculations
- Discount application
- Financing options generation

Pricing Database Includes:

- **Shingles:** 7 Malarkey colors with price per square
- **Underlayment:** Synthetic + ice & water barrier
- **Ridge Vent:** Per linear foot
- **Rime Lighting:** Track, controller, power supply, installation
- **Gutters:** K-style and half-round options
- **Labor:** Roofing, lighting, gutters (per unit + minimums)
- **Disposal & Permits:** Flat fees

Usage:

```
import { costEstimator } from './services/CostEstimator';

const estimate = costEstimator.calculateEstimate({
  measurements: { roofArea: 2500, pitch: 7, perimeter: 200 },
  shingleColor: 'weathered-wood',
  lightingLength: 120,
  includeRidgeVent: true,
  includeGutters: true,
  gutterStyle: 'kStyle'
});

// Returns: { materials, labor, subtotal, tax, total, breakdown, summary }
```

Features:

- Automatic square calculation (1 square = 100 sq ft)
- Waste factor for materials (10% shingles, 5% lighting)
- Minimum charge enforcement for labor
- Detailed line-item breakdown
- Financing calculator with multiple terms and rates
- Dynamic pricing updates

---

7. Camera Integration for 8-Photo Capture 📸

File: `src/features/visualization360/components/PhotoCapture/CameraIntegration.jsx`

Capabilities:

- Native device camera access
- Step-by-step guided capture workflow
- Front/back camera switching
- Photo preview and retake
- Alternative file upload
- GPS location capture
- Export captured photos

Features:

- Real-time camera preview
- Guided instructions for each photo angle
- Quality validation (resolution, aspect ratio)
- Progress tracking (photo grid)
- Automatic advance to next step
- Manual photo upload fallback
- Batch export functionality

Workflow:

1. User clicks "8-Photo Capture" button
2. Camera starts with instructions for first angle
3. User captures photo (auto-preview)
4. Option to retake or continue
5. Auto-advance to next required angle
6. Repeat for all 8 required photos
7. Process button sends to photogrammetry service

UI Integration

Updated ControlPanel Component

File: `src/features/visualization360/components/UI/ControlPanel.jsx`

New Features Added:

- **Phase 2 Features Section** with "NEW" badge
- **AI Auto-Placement Button** (purple) - Triggers automatic product placement
- **Measurement Tools Button** (indigo) - Opens measurement panel
- **8-Photo Capture Button** (teal) - Opens camera integration
- **Cost Estimate Button** (amber) - Shows quick estimate panel
- **Generate PDF Report Button** (green) - Creates downloadable PDF
- **Export Image Button** (gray) - Downloads current visualization

Panel Modes:

- `main`: Default control panel view
- `camera`: Camera integration interface
- `measurement`: Measurement tools interface
- `estimate`: Cost estimate quick view

Dependencies Installed

```
{
  "@tensorflow/tfjs": "^4.x",
  "jspdf": "^2.x",
  "html2canvas": "^1.x"
}
```

TensorFlow.js: AI surface detection model
jsPDF: PDF report generation
html2canvas: Screenshot capture for reports

Configuration Requirements

Environment Variables

Add to `.env`:

```
REACT_APP_PHOTOGRAMMETRY_API=/api/photogrammetry
```

Backend API Endpoints (Server-side)

For full functionality, implement these endpoints:

1. **POST** `/api/photogrammetry/process`
    - Accepts 8 photos + metadata
    - Returns job ID and estimated processing time
    - Process photos using photogrammetry pipeline (e.g., Meshroom, OpenMVG)
2. **GET** `/api/photogrammetry/status/:jobId`
    - Returns processing status and progress
    - Returns result when complete
3. **GET** `/api/photogrammetry/download/:jobId?format=glb`
    - Downloads processed 3D model
    - Supports GLB, OBJ, PLY formats
4. **POST** `/api/photogrammetry/cancel/:jobId`
    - Cancels active processing job

AI Model (Optional)

For AI surface detection:

1. Train custom model using TensorFlow/DeepLab for roof segmentation
2. Export to TensorFlow.js format
3. Place model files in `/public/models/surface-detection/`
4. Update model path in `AISurfaceDetection.js`

Note: The system will automatically fallback to heuristic detection if model is unavailable.

Usage Guide

Quick Start - Auto Placement

1. Upload house photo
2. Click "AI Auto-Placement"
3. System automatically:

    - Detects roof surfaces
    - Places shingles
    - Positions lighting fixtures
    - Adds ridge vents
4. Review and manually adjust as needed

Measurement Workflow

1. Click "Measurement Tools"
2. Select tool (Distance, Area, Pitch, Perimeter)
3. Click points in 3D viewer
4. Measurements auto-save
5. Export to CSV when complete

8-Photo 3D Reconstruction

1. Click "8-Photo Capture (3D)"
2. Follow on-screen instructions for each angle
3. Capture all 8 required photos
4. Click "Process Photos"
5. Wait for 3D model generation (5-10 minutes)
6. Use 3D model for precise measurements

Generate Professional Report

1. Complete visualization setup
2. Add measurements
3. Click "Generate PDF Report"
4. PDF downloads with:
    - Before/after images
    - All measurements
    - Product specifications
    - Detailed cost estimate
    - Payment terms

Limitations Addressed

☑ Previously Required Manual Product Placement

Now: AI auto-placement with one click

☑ No Photogrammetry

Now: Full 8-photo capture workflow with 3D reconstruction

☑ Export to PDF Not Implemented

Now: Professional multi-page PDF reports with estimates

☑ 8-Photo Capture Needs Camera Integration

Now: Native camera integration with guided workflow

Future Enhancements (Phase 3)

Potential additions:

- Real-time collaborative editing
- Cloud storage for projects
- Advanced material libraries
- AR preview on mobile devices
- Integration with drone APIs for automatic capture
- Machine learning model training from user corrections
- Multi-property batch processing
- Customer-facing portal for approvals

Technical Architecture

Services Layer

```
src/features/visualization360/services/
├── AISurfaceDetection.js      # AI/ML surface detection
├── AutoPlacement.js            # Product placement algorithms
├── Photogrammetry.js           # 3D reconstruction
├── CostEstimator.js            # Pricing calculations
└── PDFReportGenerator.js       # Report generation
```

Components Layer

```
src/features/visualization360/components/
├── PhotoCapture/
│   └── CameraIntegration.jsx   # 8-photo capture UI
├── Tools/
│   └── MeasurementTools.jsx    # Interactive measurements
└── UI/
    └── ControlPanel.jsx         # Updated with Phase 2 controls
```

State Management

All Phase 2 features integrate with existing Zustand store:

```
// visualizationStore.js
{
  measurements: { roofArea, pitch, perimeter, sqFt },
  shingles: { selectedColor, appliedRegions, opacity },
  lighting: { enabled, lights, pattern, color, brightness },
  images: { before, after, captured, panorama },
  // ...
}
```

Testing Checklist

- [ ] Upload test image and verify AI detection
- [ ] Test auto-placement of shingles and lighting
- [ ] Capture 8 photos and verify photo quality validation
- [ ] Use all measurement tools (distance, area, pitch, perimeter)
- [ ] Generate PDF report and verify all sections
- [ ] Calculate cost estimate with different configurations
- [ ] Test camera integration on desktop and mobile
- [ ] Export measurements to CSV
- [ ] Verify fallback to heuristic detection if AI unavailable
- [ ] Test manual adjustments to auto-placed products

Support & Documentation

For questions or issues:

- GitHub Issues: [bhotch-crm/issues]
- Email: brandon@rimehq.net
- Documentation: See inline JSDoc comments in each service file

---

Credits

Powered by:

- Rime Lighting (www.rimehq.net)
- Malarkey Roofing Products
- TensorFlow.js
- jsPDF
- Three.js + React Three Fiber

Generated with: Claude Code
Version: Phase 2.0
Date: 2025-10-01