HUMAN POSE ESTIMATION: UNDERSTANDING AND MODELING HUMAN MOVEMENT

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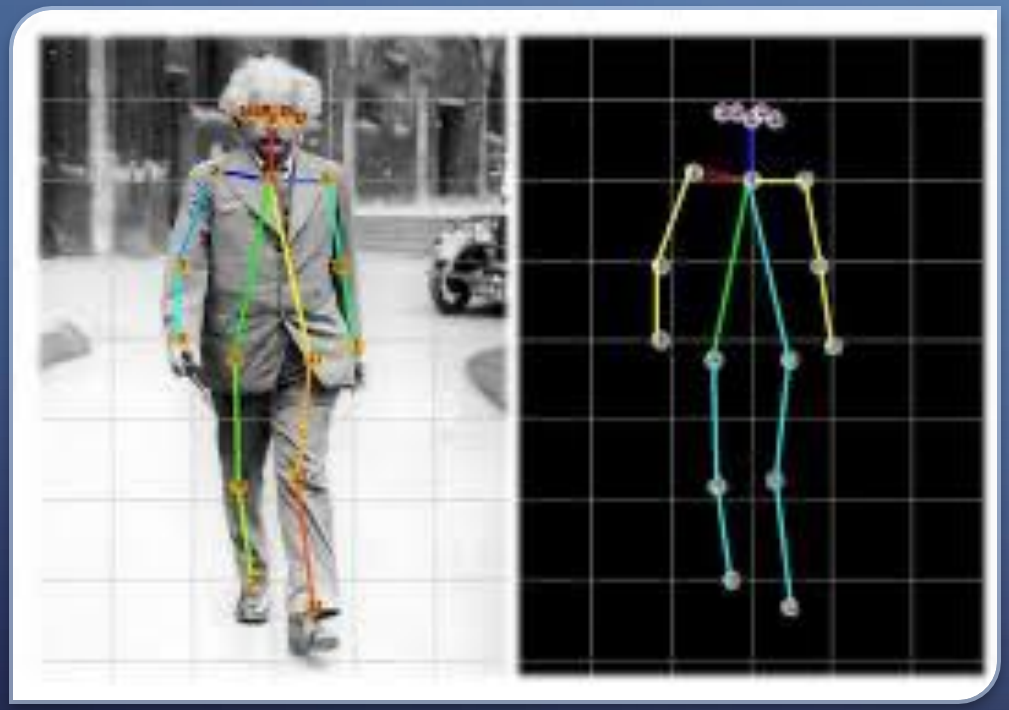
DECEMBER 4, 2025

WHAT IS HUMAN POSE ESTIMATION?



- Detect key body joints
- Connect joints to form a skeleton
- Analyze human movement in images and videos

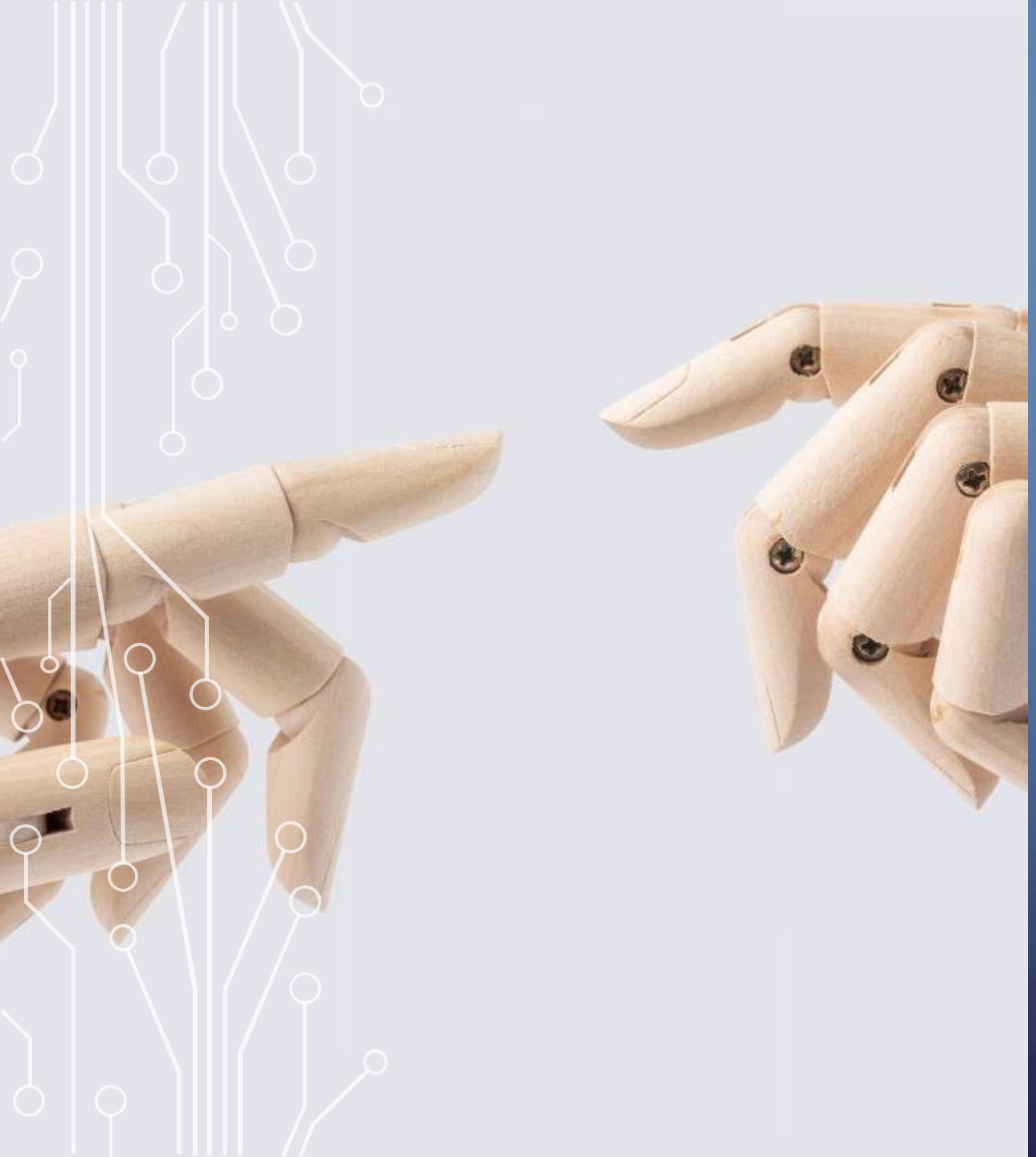
APPLICATIONS

Sports analytics: track player movement

Animation & gaming: motion capture

Healthcare: position / rehab monitoring

Human-computer interaction: gesture control



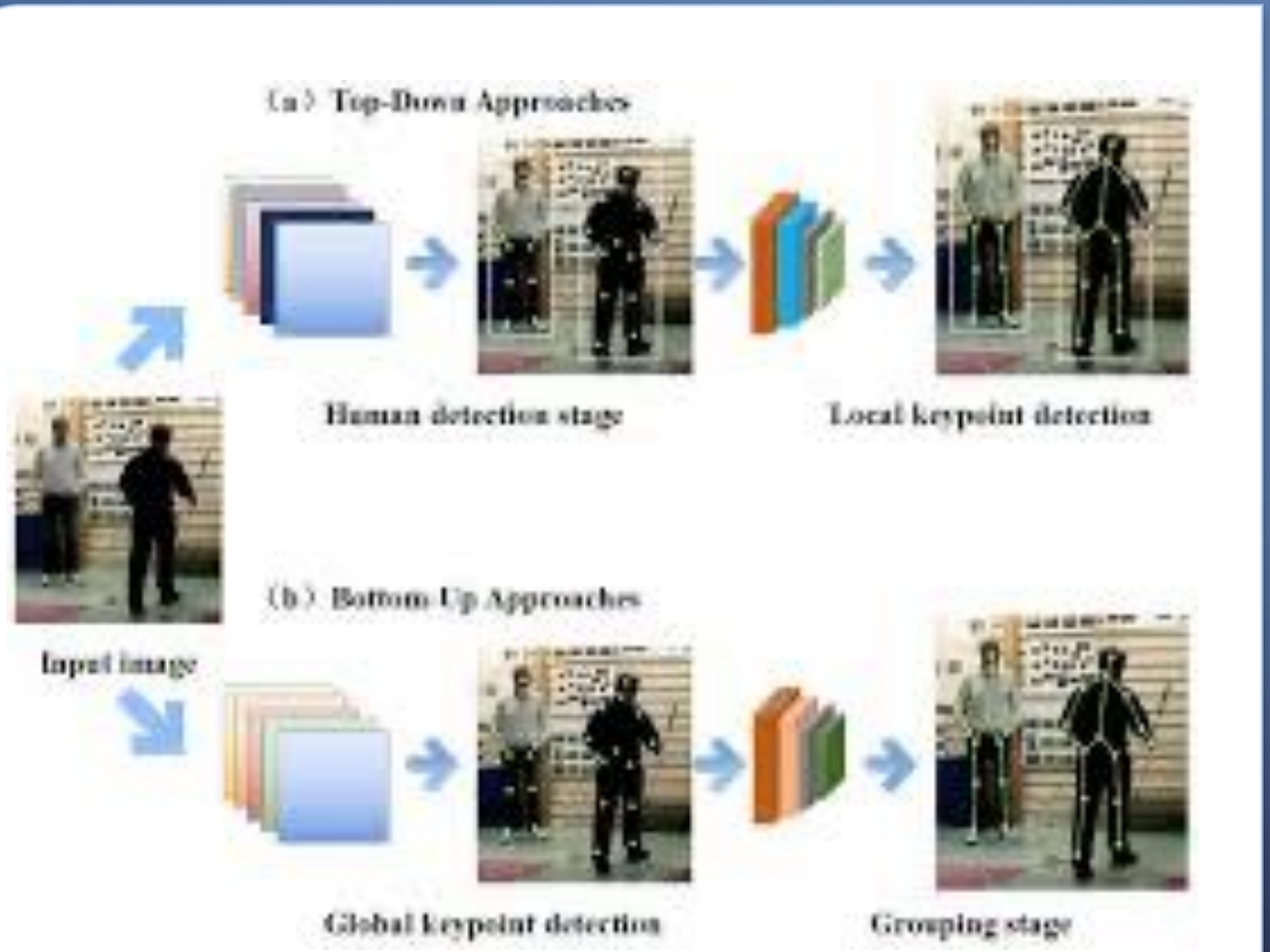
KEY CONCEPTS

- Keypoints: joints
- Skeletons: connect keypoints to visualize posture
- 2D vs 3D: 2D is simpler; 3D adds depth

(a) (b) (c) (d)

CHALLENGES

- Occlusion: body parts blocked
- Multiple people in the image
- Variation in clothing, lighting, camera angles
- Real-time video requires fast processing



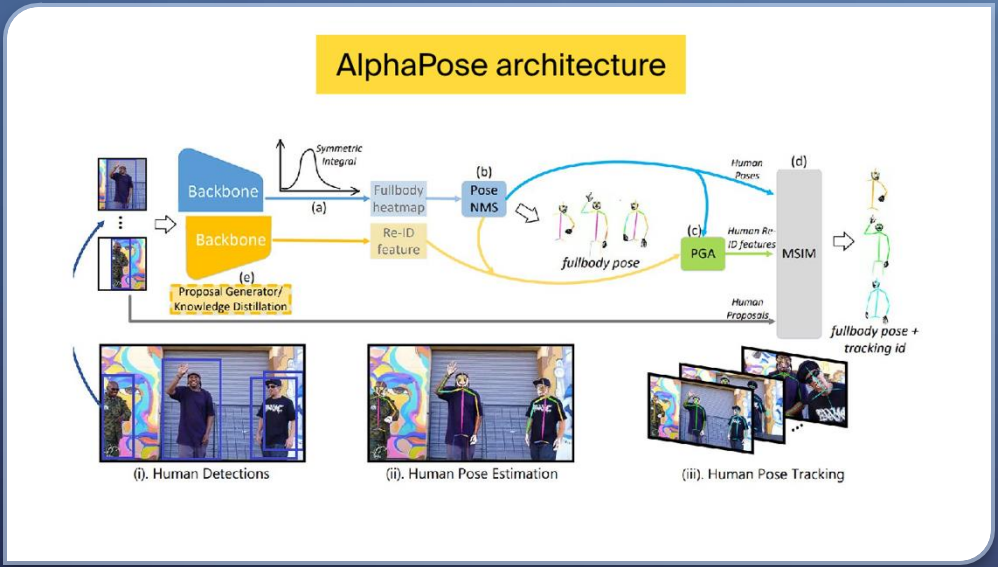
APPROACHES

- Top-down: detect people → then keypoints
- Bottom-up: detect all keypoints → group into people

POPULAR MODELS AND TECHNIQUES

- OpenPose: real-time multi-person 2D pose estimation
- HRNet: maintains high-resolution features
- PoseNet: lightweight, runs in-browser or on mobile

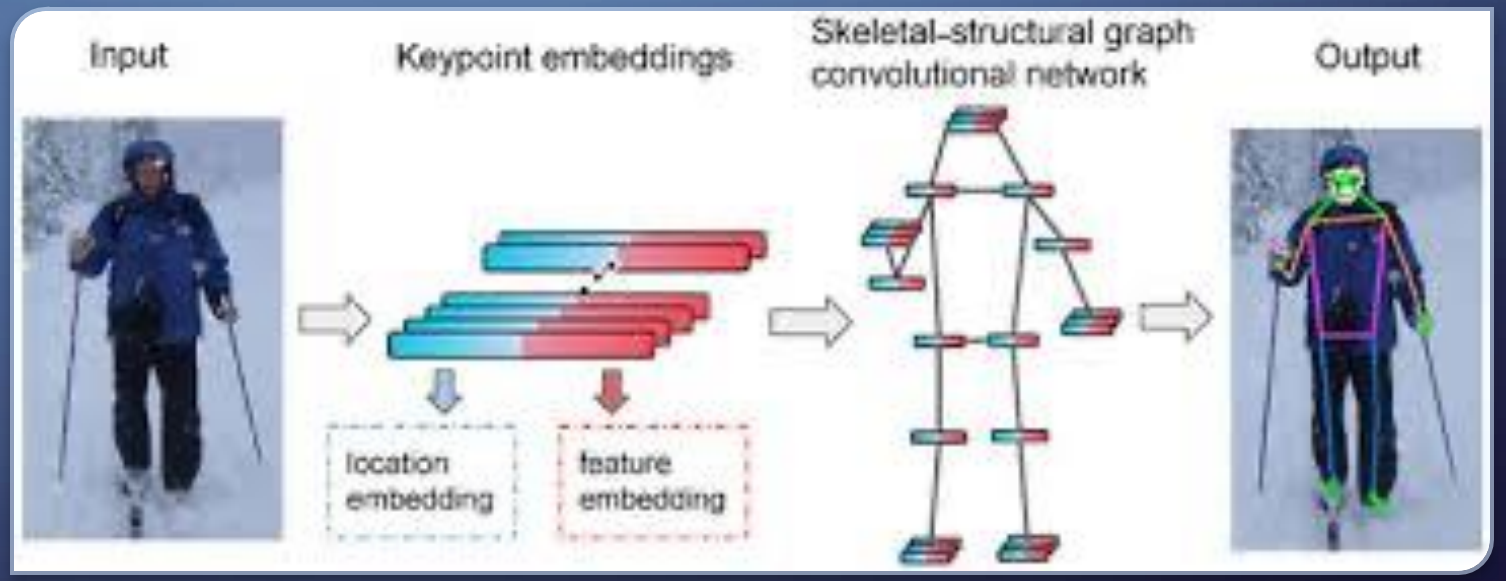
HOW POSE ESTIMATION IS MODELED



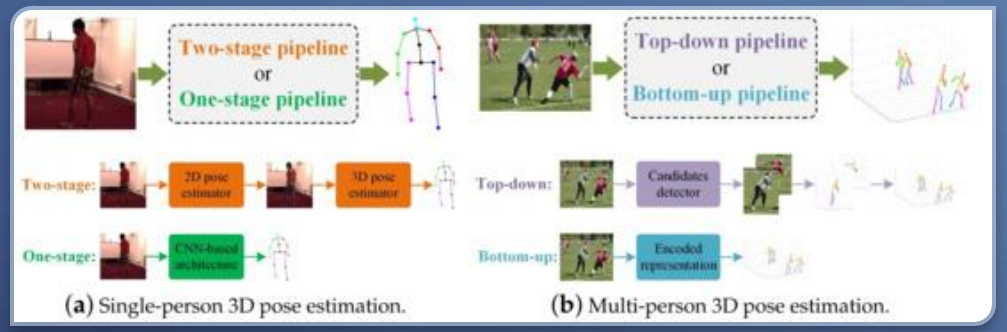
- Uses convolutional neural networks (CNNs) to extract image features
- Outputs heatmaps for each keypoint
- Loss function compares predicted vs. true keypoints
- Training on images with labeled keypoints

MODEL ARCHITECTURE AND TRAINING WORKFLOW

- Backbone CNN extracts multi-scale features
- Feature maps passed through refinement layers
- Heatmaps decoded to keypoint coordinates



ADVANCED MODELING AND OPTIMIZATION TECHNIQUES



- Multi-person pose estimation: top-down vs. bottom-up pipelines
- Data augmentation: rotation, scaling, flipping for robustness
- Loss functions: MSE for heatmaps, PCK-based penalties
- Optimization: Adam or SGD, learning rate scedules

MODERN ENHANCEMENTS AND DEPLOYMENT

- Lightweight architectures for mobile / embedded devices
- Real-time optimizations: model pruning, quantization
- Integration with video pipelines for smooth temporal tracking
- Multi-task learning: pose + action recognition
- Pretrained models and transfer learning

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