PREPOSE: Security and Privacy for Gesture-Based Programming

Lucas Silva Figueiredo Federal University of Pernambuco Benjamin Livshits, David Molnar, and Margus Veanes Microsoft Research





VR + GESTURE SENSING



+

AR + GESTURE SENSING



GESTURE SENSORS — ALL SORTS AND SIZES



PROBLEM: PRIVACY APPLICATIONS CAN ACCESS SENSITIVE DATA

PROBLEM: SAFETY



Just because **you can ask** the user to make a gesture **doesn't mean you should**.

Prepose can check if an app asks the user to move in a **dangerous way**.

PROBLEM: CONFLICTS



Do any apps try to **override** the system attention gesture?

Could any **two gestures** be triggered at the same time?

PROBLEM: BUILDING NEW GESTURE RECOGNIZERS

```
// Punch Gesture
if ( vHandPos.z - vShoulderPos.z > fThreshold1 &&
    fVelocityOfHand > fThreshold2 ||
    fVelocityOfElbow > fThreshold3 &&
    DotProduct( vUpperArm, vLowerArm) > fThreshold4 )
{
    bDetect = TRUE;
}
```

PROBLEM: BUILDING NEW GESTURE RECOGNIZERS

Machine Learning Approaches



Modeling Variations

ML Knowledge

Data Set Size

Recording and Tagging

Editing the Gesture

Recognition Time

Detailed Feedback

Conflicts

PREVIOUS APPROACHES

Limited access (Jana et al. 2013 x2, Vilk et al. 2015)

- Color frames
 - Visuals of the environment and users
- Depth frames
 - Shapes which can be used to automatically detect objects and furniture
- Silhouettes
 - Presence, clothing, weight
- Skeletons
 - Processed information about the user

Add noise (Jana et al. 2013)





OUR APPROACH



UNDERSTANDING A PHRASE IN PREPOSE





OUR WORK: PREPOSE



Fourth position en avant of the arms (with the feet in the fourth position croisée). GESTURE fourth-position-en-avant: POSE cross-legs-one-behind-the-other: put your left ankle behind your right ankle, put your left ankle to the right of your right ankle.

> POSE high-arc-arms-to-right: point your arms down, rotate your right arm 70 degrees up, rotate your left elbow 20 degrees to your left, rotate your left wrist 25 degrees to your right.

EXECUTION:

cross-legs-one-behind-the-other, high-arc-arms-to-right.

CHECKING SAFETY WITH Z3



STATIC ANALYSES: CONFLICTS



Do any apps try to **override** the system attention gesture?

Could any **two gestures** be triggered at the same time?



EVALUATION

Expressiveness

Application	Gestures	Poses	LOC
Therapy	12	28	225
Ballet	11	16	156
Taichi	5	32	314

Speed

Performance	Online	Offline
30 FPS	Matching time: 3 ms	Safety: 725 ms
	Pose transition: 91 ms	Conflicts: 52 sec

CONCLUSION

- 1) Prepose: a **language** for expressing gestures
- 2) A **runtime** for creating always-on training applications using Prepose
- 3) Support for user **privacy** built into system design
- 4) An approach to checking gesture **safety and conflicts** between gestures
- 5) Ability to **check** gestures and their composition using Z3 at app submission

FUTURE WORK

New actions/primitives to improve expressiveness

Make use of time based constraints (slowly, fastly)

Reusable gestures as assets on a store

Example applications

Add sensors: Leap Motion, Intel Real Sense, etc



arm_down rot_up

2 times

_ □

DOWNLOAD IT AT

github.com/microsoft/prepose We take pull requests!

GESTURE RECOGNITION POWERS KINECT APPS







GESTURE SENSORS



PROBLEM: PRIVACY IS A MAJOR CONCERN

Privacy concerns threaten to overshadow Microsoft's new console

By Brian Crecente on Jun 05, 2013 at 11:14a @crecenteb

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 he Xbox One brings with it a required peripheral packed with microphones and cameras that can monitor a person's every

IN THIS STORYSTREAM

Mandatory Kinect on Xbox One raises privacy concerns

- O Aug 12 219 comments Xbox One will still function, even without Kinect plugged in (update)
- Jun 5 160 comments
 Privacy concerns threaten to overshadow Microsoft's new console
- May 30 10 comments Taiwanese animators take on the Xbox One, consumer privacy and Kinect's gigantic ear

6 Updates

Xbox One will still function, even without Kinect plugged in (update)

By Dave Tach on Aug 12, 2013 at 5:42p @dptach





IN THIS STORYSTREAM

Mandatory Kinect on Xbox One raises privacy concerns

- Aug 12 219 comments Xbox One will still function, even without Kinect plugged in (update)
- O Jun 6 57 comments Kinect on Xbox One will not record or upload your conversations, Microsoft says

6 Updates

KINECT ENABLES NATURAL USER INTERFACE (NUI)





20M - 2016

SMART HOUSES/WORKPLACES





EXPRESSIVENESS: BALLET



APP ballet:

GESTURE first-position: POSE stand-straight: point your spine, neck and head up.

POSE point-feet-out: point your right foot right, point your left foot left.

POSE stretch-legs: align your left leg, align your right leg.

//POSE put-ankles-together:
//connect your right ankle to your left ankle.

POSE low-arc-arms:

point your arms down, rotate your elbows 15 degrees up, rotate your left wrist 5 degrees to your right, rotate your right wrist 5 degrees to your left.

//POSE first-position-composed:
 //stand-straight,
 //point-feet-out,
 //stretch-legs,
 ////put-ankles-together,
 //low-arc-arms.

EXPRESSIVENESS: TAICHI



APP taichi_gestures:

GESTURE starting: POSE stand_straight: point your spine, neck and head up.

POSE starting_legs:

point your legs down, rotate your right leg 10 degrees to your right, rotate your left leg 10 degrees to your left, point your feet to your front.

POSE starting_arms:
point your arms down.

POSE inhale_arms:
point your arms to your front.

POSE transition_arms:

put your left wrist in front of your left shoulder, put your right wrist in front of your right shoulder. //put your left wrist near to your left shoulder, //put your right wrist near to your right shoulder, //move your spine shoulder 10 centimeters to your back

POSE bend_your_knees_slightly:

don't align your left knee and your left ankle, don't align your right knee and your left ankle.

CONCLUSION

Novel way to write gesture recognizers

Alternative to existing machine learning approaches

Architecture protects privacy

Expressive enough for a wide class of gestures

Resulting recognizers run quickly

First gesture recognizers with precise static analyses

COMPLEMENTARY TO MACHINE LEARNING

Declarative

Close to English

Easy to understand and refine

Fast coding and prototyping

Reusable components

Open to different interpretations of the underlying actions

Analysis Power

Safety

Conflict Detection

Target Generation

FOCUS: TRAINER APPLICATIONS

Always on

Monitors user's progress

Only needs to report progress or completion

May run concurrently (e.g. passive health monitoring)

PRINT SCREENS



PHYSICAL THERAPY









COMPLEX GESTURES





PREPOSE: PRIVACY, SECURITY, AND RELIABILITY FOR GESTURE-BASED PROGRAMMING

Lucas Silva Figueiredo

Benjamin Livshits David Molnar Margus Veane