Participant: …any more. I would give the circle that showed that I had it. So there's some alignment problem.

Proctor 1: I see there's an alignment problem between the robot and the… Is it working?

Proctor 2: No. It won't connect to it, I guess.

Proctor 1: Okay, let me, let me just see something. Sorry for that again. It was just working before you came.

Participant: Yeah, yeah. Now, why did you choose to use a bounding box solution rather than playing off of an individual's hands? Because then they don't have to do any grabbing, You just move your hand.

Proctor 1: The point is, this is the second phase of this study. What we did in the first phase, we compared different types of interfaces in mixed reality. One of them, they could just just use free hand mode where they could just pinch the gripper and move it, move it where they want it. But the problem is, depending on the tasks, the tasks that you are doing, especially on tasks that require precision, it will not work as expected, and then they get super frustrated. We ask you then, for example, to move… We ask you then, for example, to move a gripper to a specific position and we gave them like X-, Y- and Z- coordinates. And when we did that, because their hand detection was not super precise, their hand was kind of shaking, and then they got super frustrated. So, that's why we are using [the] bounding box; because in terms of usability, bounding box was the winner. We compared like- I can show you the paper.

Participant: That's all right. I get it. Mm hmm.

Proctor 1: We also compared other approaches, like sliders and buttons; and, this was the best one, according to them, Like, manually adjust the robot. But it's not about, like, just general movement. It's more like- Okay.

Participant: How did it compare with, say, just doing a game controller kind of approach?

Proctor 1: How did they turn?

Participant: Well, I mean, this seems awfully dangerous to have people flailing around, equipment reaching to grab bounding boxes.

Proctor 1: I agree. But, yeah, we-

Participant: What about a game controller; because then, they stay within their own little space.

Proctor 1: Yeah, this is an option. Joystick, for example. That's how the controllers do, but we are honestly more focused on, like, lead-through mode. So, we want to propose something that is similar to lead-through; where you grab your hands and do it. And yeah, I mean, the point is we are trying to create something that minimizes the complexities of a robot. Like one of them, one of the things that we tried, is [a] joystick; not a physical one, but one in mixed reality. And they also got confused, you know.

Proctor 1: Why is it not working? I mean. Oh, I see. I see now, Chandler, it's because we are on the wrong wi-fi. This is my headset?

Proctor 2: Yea.

Proctor 1: This is- If you have something to do, it's fine. So sorry for that, but… It should work now. It wasn't the VCU wi-fi, that's the reason. We can't use the VCU wi-fi for this kind of communication, so we have our own router; that, right there.

Participant: Ah, got it.

Proctor 1: And then what sometimes happens is the Hololens, because this is an offline network, it tries to find a network that actually works.

Participant: Right, right, right.

Proctor 1: Sorry. Yeah, that's why it's not communicating. We are here, like, trying, and I was like, “what’s happening?” Okay. Connect, and now it should work. Stop these... Okay, now we are in the correct connection.

[Audio Gap, ends at 6:30]

Participant: All right!

Proctor 2: Yes, you can, I know you're almost out of time, so we'll just, I guess, play with it and…

Participant: Oh, okay. Now, it's working. Okay, first time with a Hololens on: is there a way to get more peripheral vision?

Proctor 2: No. That's one of the limitations of the HoloLens.

Proctor 1: Specifically the HoloLens.

Participant: Yeah, because it's, I mean, because it’s cheap.

Proctor 2: There's other glasses that are, like, way better.

Participant: Triple, quadruple the price…

Proctor 1: Yeah, there are some Chinese startups that are even way more.

Participant: So full on, almost helmet-y, wrap-around stuff. Okay. All right.

Proctor 2: And another method of grabbing, too- If you step back, sometimes you can have, just, like, a pointer extending from your fingers, and you kind of use that.

Participant: Yeah, I'm having trouble now. It's- It could be my vision. I'm wearing contacts; and so, just, the depth perception is a little challenging of figuring out how to

grab it, whether I know I have grabbed it, and then, I guess the, the, pacing; that is: how fast should I do it?

Participant: How do you make it go down?

Proctor 2: Yeah. The ones on the bottom and the top.

Proctor 1: I feel that the ones at the top [and] the bottom are the worst ones. They're kind of complicated things.

Participant: Can you move it up and down with the side?

Proctor 1: No. You can, from the side you can-

Participant: It's just like, see; because, I don't want to put my hand underneath it, I think it's dangerous. I can't. I can't. The one at the top isn't grabbing.

Proctor 2: Try stepping back from a little bit, and then just point at it. I think there are things a little delayed, but as you point, if- You should see a pointer leaving your fingers. You should see a dashed line. If you look, [it] looks like it's a little bit above your head right now.

Participant: Well, I see the ring. I don't see a dashed line. All right. Now, I just spun it. Oh, because I hit the edge. Is there a way to snap it back because I made a bad move? Or do I have to surgically return it to you?

Proctor 1 & 2: No.

Proctor 2: No, you have to-

Participant: Okay. So, maybe that would be a really good feature. [It] is to have a snap *[snaps fingers]* or something to have it undo the last move in case you just screw it up. Like, snap *[snaps fingers]* and it comes back. … Yeah, and how I grasp is very challenging. I don't know when I've grasped or not.

Proctor 1: So, there's a lack of feedback, basically, right?

Participant: Yeah. Okay. So, now I saw a laser coming out of my hand. All right, so I can see that and- Whoa, whoa, whoa. Okay. So now, let's try to grab this one. Oh yeah, I can't go up and down with that. I have to go down at the bottom.

Participant: How can I grab the top of the bottom? It's not…

Proctor 1: You can pinch it as you did with the other ones.

Participant: But it's not- These are getting in the way.

Proctor 1: I see. Yeah. Yeah. So-

Participant: So I can't, I can't get at it.

Proctor 1: This is a problem that we noted; because, in the first phase of the experiment, we were not using a physical robot. They were just manipulating holograms. And so they did- They didn't face these kind of problems. But now that we're trying with, you know, a real, physical robot, you face this kind of problem; especially for the top and down.

Participant: Yeah. And yeah, well, it doesn't seem- Wherever the sensor is that's picking up my hands, it's having trouble seeing. Kind of- I can't get at the bottom. Okay, and now I can't get it at the top because I picked these up.

Proctor 1: So but if you try to use left and right, is it easy to like to manipulate the holders on the left or…?

Participant: Well, sort of. It's nice and responsive. It's difficult to know when I grabbed it, and then like, how do I push? I can't. I can only pull. Because, I can't get it to spin this way now. So I, I'm highlighting and now I think I'm touching the thing I'm supposed to be touching.

Proctor 2: Try to put your hand up, I guess.

Participant: Well, then the laser beam goes off. So right now I'm pointing at it… There we go. And then you've got to, like, almost snap your hand open to know that it's done. Let's try to make it go down.

Proctor 1: This is also a problem, I would say, more related to the HoloLens. It has some kind of delay to detect that you're not pinching anymore. So, this is something we need to work on.

Proctor 2: So, while you're working on it, what are you, kind of, finding good and bad about it?

Participant: Well, I think when I actually grab it and it's responsive, it seems to work. The challenge I'm having is grabbing anything. Because of the way these are all positioned, say, in the center of the bounding box, it makes it very difficult to grab them. So perhaps one strategy would be to have this in the lower third, this in the upper third, and this in the middle, so that the laser beams don't get in each other's way.

Proctor 1: I see.

Participant: Now, another challenge is if I'm in this position, I can't touch the bounding box back here; because, I've got to shoot through this plane to get there. So now I've got to move over here. Yeah, and I'm not sure. You know, so I don't know how that's going to work.

Participant: Let's see, I still haven't made it go down.

Proctor 1: Yeah-

Participant: Yeah, I can get it to go left and right. That's working. I think I made it go up.

Proctor 2: Yeah, there's just a lot of issues gripping it, and confirming that you've actually gripped it.

Participant: Yeah, confirming that I gripped, and then I've figured out that I've got to do this.

Proctor 1: All right. I understand. Yeah. But, yeah, one of the problems with [the] bounding box is that it looks like a collidable object, so you cannot go through it, right? And then you have to, like, move in different directions to pinch whatever you are trying to pinch.

Participant: You know, it's interesting… I can't grab it to make it go down.

Proctor 2: I think one of the- Yeah. If you put your hand in front of the Hololens so it's no longer detecting *[unintelligible]*.

Participant: Yeah. I can't. I can't figure out how to make it go down. I, I do figure and I think I have this figured out.

Proctor 1: The right one?

Participant: The right one, and this one figured out. Here we go. And then this one. Yeah. This one isn't picking up a pinch. But these two do. This, let's see this one. Here we go. That one isn't good in any motion.

Proctor 2: So what are your ideas to improve? So, at the top with the translation of up and down..

Participant: Yeah, well, I see that, I see the challenge is that you can only work on a single axis, and what you're trying to do is provide a way to allow a user more simply to do an axis. Because if you were to joystick it or do three axes, you wouldn't know whether they're pushing or pulling. So I can see that. But for example, this one. I'm having trouble. I don't know if there's a way to decrease the sensitivity. Whoa. See, I just caught that. And I, I've been trying to do that, but I haven't been able to do it. But I still have to figure out how to make it go down. Can you make one of these here be able to go up or down or are you only allowing-

Proctor 1: Yeah, we can, we can-

Proctor 2: -do whatever you want-

Proctor 1: -but not right now, right?

Participant: Yeah. I think, I think if you could provide a single point: instead of letting these operate on a single axis, allow them to operate on a plane so that I could grab this and go up or down or left or right.

Proctor 1: I see.

Participant: Because then I can operate on this plane and it's only one grab. Grabbing seems to be the most frustrating part; and once you've grabbed it, you're good and you can do your thing. So, if I had a plane and I could touch this one- Oh, I could do it now… But now I can't go left or right. But if I could, if I could grab and move it on the left or right or up or down, I think that would be one grab and then a move. And then I could go over to this side and do one grab and then a move. And then these... So now I'm not even really grabbed, but I like that. Now, I'd like to be able to go down.

Proctor 1: But you can't.

Participant: But I Can't.

Proctor 1: Yeah, I see.

Participant: And so if I, If the blues would let you not just do left or right but do it up and down, then I don't need to worry about the top.

Proctor 1: The top one.

Participant: And I don't need to worry that my head is in the middle and I'm shooting through a plane to get at the top controls; because, that may...

Proctor 2: The controller in the back are kind of useless.

Participant: The ones on the back are useless. So if you could give me this one right here in the front where I could do a left or right or up or down…

Proctor 1: Yeah.

Participant: …and then I could do one of these to get it aligned front and back. And then, I don't know, then I'd have to play some twisty games, and that could be where I would grab one of these at the bottom and then spin it or push it. And so then I get two actions. So, maybe that's the game. The game is to allow two claim controls on each of these instead of one claim control.

Proctor 1: I see. Yeah. Just let you know, like what we are doing here is more like using the native features of HoloLens right now. So we are not building a product based on what we really want to do. So yeah, first getting feedback, and one of the problems with the just moving it like in the front isn't the print holder [is] that: we've noticed that, the way that we have now, is that sometimes the user is trying to go left and right, but then it goes up and down; and, they get frustrated because they didn't want to go up and down. So one of the things that we're trying is to, like, have buttons or an interface where you can lock the axis that you want.

Participant: Yeah.

Proctor 1: Because that's also a problem. I understand that just using one holder would solve the problem. But then you have another problem: do I really want to go up and down now, or do I just want to go left and right?

Participant: Right. Well, it seems to also have trouble detecting when you pinch or not.

Proctor 1: Yeah. Yeah.

Participant: And then I'm finding it's very difficult to get my vision to match where the ring appears or where the axes appear. I was having trouble. It seemed to be overly sensitive when it was either selecting a plane or selecting a plane because it wasn't reading my hand or I hadn't figured out how to do my hand right.

Proctor 1: Yeah. Yeah.

Participant: So I mean, it's just iteration; that's experimentation. This is out on the edge.

Proctor 1: Is there any other questions?

Proctor 2: Yeah, just once more questions that we want to ask: do you see any, like, real world or industrial applications of this where it would be useful?

Participant: Well, I can see if you're, if you're wanting to manipulate something in a controlled environment and you're outside that controlled environment, just doing this would be a pain in the butt; because I mean, I would just assume grab the top and move the robot around. And in fact, maybe almost if you could build the cube out here and put a hand in the cube and allow this kind of stuff. You'd have to turn it down so that it's not very sensitive or, you know, quivers would make the thing jiggle, but that that would be- That would seem to me that if the focus was on here, and I'm moving that left and right and maybe turning left and right; and, then having all the math do the translation to kind of shift this thing this way or shift it this way, so that the motion is restricted here. That would make an awful lot of sense. Trying to manipulate this big box when I'm really trying to reach here and grab is kind of tricky. Yeah, but the math to keep this position and move the arm would just be nuts. I mean, it's math; you just program it in and do the transformation and you're good. But, yeah. I don't know. The only thing I can think of is, for example, if you were doing sandblasting, you know, and you had this sandblasting cage… That [what] you may want to do, instead of putting your hand in the gloves and doing all this, although that works pretty good, if you couldn't have gloves because the shit that's in there eats gloves, then I can see you'd want to be working out here. But again, I can't see that you'd want to get your hands in gloves and have this be doing all that. But the bounding box stuff, I can't see..

Proctor 1: Oh yeah, I understand. Yeah. That's definitely one of the applications that we are aiming for. Because right now, we are working with cobots, and with cobots, you can definitely just come here and do lead-through mode, grab it and move it. But, when we're talking about all the other industrial robots available who are not collaborative, you

cannot do that. So they are in a cage, and one thing that you could do is you have a holographic gripper manipulated from the outside and see it, you know, …

Participant: What would be really cool, and your software probably doesn't do it, is that if you could do a virtual image of this and then I can hold that and move it around…

Proctor 1: I see. Where-

Participant: … and twist or not. And I'm manipulating this.

Proctor 1: Yeah, that's, that's exactly what it would be. I can, I can show you. That's exactly what we did in the first place.

Participant: Yeah.

Proctor 1: We have a 3D model of the gripper and, you know, …

Participant: You know, the pinch is kind of- I found difficult. If you could make it bigger so that you could grab; so, that if it more matched your hand- This little surgical thing is very difficult and frustrating to try to get it just right.

Proctor 1: Yeah. Yeah. I agree.

Participant: Yeah. Yeah. No, this is cool. This is cool.

Proctor 1: Yeah. It's perfect. Thank you for trying [it].

Participant: Are there other questions? Okay. But my office is right here.

Proctor 1: Awesome

Participant: You know, and you can grab me and I'll, I'll come in and drop 30 minutes or something.

Proctor 1: Thank you so much for another great feedback.

[Omitted the rest due to relevance.]