

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

1	CYWEE GROUP LTD.,	)	
2		)	
3	Plaintiff,	)	
4		)	Case No.
5	vs.	)	2:17-CV-00140
6		)	-RWS-RSP
7	SAMSUNG ELECTRONICS CO., LTD.,	)	
8	AND SAMSUNG ELECTRONICS	)	
9	AMERICA, INC.,	)	
10	Defendants.	)	
11	_____	)	

DEPOSITION OF
JOSEPH J. LAVIOLA, JR., PH.D.
Orlando, Florida
Wednesday, March 7, 2018

Reported by:
RHONDA HALL-BREUWET, RDR, CRR, LCR, CCR, FPR,
CLR, NCRA Realtime Systems Administrator
JOB NO. 138800

1
2
3
4 March 7, 2018

5 8:05 a.m.
6
7

8 Deposition of JOSEPH J. LAVIOLA,
9 JR., PH.D., held at the Doubletree, 12125 High
10 Tech Avenue, Orlando, Florida 32817, before
11 Rhonda Hall-Breuwet, Registered Diplomate
12 Reporter, Certified Realtime Reporter, Licensed
13 Court Reporter (TN), Certified Court Reporter
14 (GA and LA), Florida Professional Reporter,
15 Certified Livenote Reporter, NCRA Realtime
16 Systems Administrator, and Notary Public of the
17 State of Florida.
18
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20
21
22
23
24
25

1 A P P E A R A N C E S:

2 ATTORNEYS FOR PLAINTIFF:

3 SHORE CHAN DEPUMPO

4 901 Main Street

5 Dallas, Texas 75202

6 BY: ARI RAFILSON, ESQUIRE

9 ATTORNEYS FOR DEFENDANTS:

10 PAUL HASTINGS

11 4747 Executive Drive`

12 San Diego, California 92121

13 BY: BOB CHEN, ESQUIRE

14 STEVEN MOSELEY, ESQUIRE

----- I N D E X -----

WITNESS: JOSEPH J. LAVIOLA, JR., Ph.D.

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----- E X H I B I T S -----

NUMBER		MARKED
Exhibit 1	Declaration of Joseph J. LaViola, Jr., Ph.D., dated 1/12/18; Curriculum Vitae of Joseph J. LaViola, Jr., Ph.D.	12
Exhibit 2	Declaration of Joseph J. LaViola, Jr., Ph.D., dated 2/23/18	15
Exhibit 3	U.S. Patent Number 8,441,438	16
Exhibit 4	U.S. Patent Number 8,552,978	152

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 acknowledged having been duly sworn to tell
3 the truth and testified upon his oath as
4 follows:

5 THE WITNESS: I do.

6 DIRECT EXAMINATION

7 BY MR. CHEN:

8 Q. Could you state your full name for
9 the record, please.

10 A. Joseph J. LaViola, Jr.

11 Q. And you've been retained by CyWee as
12 an expert witness in this case; is that
13 right?

14 A. Yes.

15 Q. And you understand that you're under
16 oath today?

17 A. Uh-huh.

18 Q. Before we get started, have you ever
19 been deposed before?

20 A. No.

21 Q. So then before we begin, I'd like to
22 start by just going over some ground rules
23 for this deposition.

24 Is that okay?

25 A. Yeah.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. So you see we have a court reporter
3 here, so everything that we say is going to
4 be transcribed, so it's important that we
5 don't speak over one another. So I'm going
6 to try my best not to do it to you; if you
7 could try your best not to do it to me.

8 Is that okay?

9 A. Yeah.

10 Q. And because we have a court
11 reporter, we want a clean record. It's
12 important that you give me full and complete
13 answers to my questions.

14 Is that okay?

15 A. Yeah.

16 Q. So from time to time I might ask you
17 a question that you don't understand. It's
18 perfectly okay for you to just ask me to
19 repeat my question or reframe or restate.

20 Is that okay?

21 A. Yes.

22 Q. If you need a break at any time,
23 just let me know. I will try to accommodate
24 you as soon as I can. I might try to finish
25 a line of questioning before we stop.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Is that okay?

3 A. Yeah.

4 Q. Is there any reason that you can't
5 give your best testimony today?

6 A. No.

7 Q. Are you on any medications or drugs?

8 A. No.

9 Q. Are you feeling ill?

10 A. No.

11 Q. Is there any other reason why you
12 might not be able to answer my questions
13 fully and completely?

14 A. No.

15 Q. To start, just sort of an overview
16 of your background -- can you give me sort of
17 just a high level of your educational
18 background.

19 A. I got my bachelor's degree in
20 computer science from Florida Atlantic
21 University in 1996. I got a master's degree
22 in -- at Brown University in computer science
23 in 2000, master's degree in applied
24 mathematics in 2001, and a Ph.D. in computer
25 science in 2005. I'm a professor at the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 University of Central Florida, where I teach
3 computer science.

4 Q. And the master's degree and the
5 Ph.D., are these both from Brown?

6 A. Yes.

7 Q. And so you're currently teaching
8 computer science at the University of Central
9 Florida?

10 A. Uh-huh.

11 Q. How long have you been teaching as a
12 professor there?

13 A. Since the -- January of 2007.

14 Q. And did you have a prior
15 professional position before becoming a
16 professor?

17 A. I was a postdoc at Brown University
18 from 2005 to 2007.

19 Q. So you graduated -- sorry. You got
20 your Ph.D. in computer science in 2005 and
21 then the postdoc from 2005 to 2007, and then
22 you became a professor?

23 A. Yes.

24 Q. And that's your current position?

25 A. Uh-huh.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. And that's the only professional
3 position you've --

4 A. I'm a consultant.

5 Q. Consultant?

6 A. Uh-huh.

7 Q. What kind of consulting work do you
8 do?

9 A. I do expert witness work. I also
10 consult for companies.

11 Q. What kind of companies?

12 A. Virtual and augmented reality
13 companies.

14 Q. What kind of consulting work do you
15 do with the virtual augmenting companies?

16 A. It's mostly user-experience review,
17 user-interface analysis. I also provide
18 expertise in various algorithmic work related
19 to motion tracking, gesture recognition,
20 other interface-related things.

21 Q. Can you give me sort of a time frame
22 for your consulting work? Is that --

23 A. It varies.

24 Q. So did you start out as a postdoc
25 or --

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. I started as a Ph.D. student.

3 Q. As a Ph.D. student?

4 A. Uh-huh.

5 Q. So for this litigation, when were
6 you first contacted about this matter?

7 A. I believe it was sometime in the
8 summer of last year.

9 Q. Do you know who -- do you remember
10 who contacted you?

11 A. Yeah. It was a -- one of these
12 expert witness placement firms, Rubin/Anders.

13 Q. Okay. Do you just work with
14 Rubin/Anders, like your name is part of their
15 portfolio of experts?

16 A. Yeah. I mean, it is now. I was --
17 I hadn't worked with them before, but then
18 there was -- they found me and, you know,
19 they said "Would you be interested?" and I
20 said, "Sure."

21 So now I am on their list of, you
22 know, potential clients or potential expert
23 witnesses.

24 Q. So have you worked with other expert
25 witness firms before?

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Yes.

3 Q. Which ones?

4 A. Company called IMS.

5 Q. Any others?

6 A. No.

7 Q. What were you asked to do?

8 A. For what?

9 Q. For this litigation.

10 A. I was asked to --

11 MR. RAFILSON: And I'll caution the
12 witness not to provide details of any
13 communications. He can speak generally
14 on what he's been retained to do but not
15 provide details because that's
16 privileged.

17 A. Yeah. I was asked to examine
18 patents and to provide commentary on them.

19 MR. CHEN: Mark this as Exhibit 1.
20 (Exhibit Number 1, Declaration
21 of Joseph J. LaViola, Jr.,
22 Ph.D., dated 1/12/18;
23 Curriculum Vitae of Joseph J.
24 LaViola, Jr., Ph.D., was marked
25 for identification.)

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 (Off the record from 8:15 a.m.
3 to 8:15 a.m.)

4 BY MR. CHEN:

5 Q. Do you recognize this document?

6 A. Yes.

7 Q. What is this document?

8 A. This is my declaration on claim
9 construction.

10 Q. And you signed this one -- it's the
11 first one -- on January 12th of this year; is
12 that correct?

13 A. Yes.

14 Q. How many hours did it take you to
15 write this declaration?

16 A. The original declaration or direct
17 declaration that was modified after
18 Dr. Mercer's declaration?

19 Q. So this is the original one.

20 A. This is the original one? Okay.
21 This one took me about, I want to say, maybe
22 18 hours.

23 Q. And did you work with CyWee's
24 counsel to prepare this?

25 A. Yes.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. What materials did you use to
3 prepare this declaration?

4 A. I used the patents, file wrappers,
5 claim construction materials, and some other
6 extrinsic information, some various documents
7 I found on the Web. Can't remember off the
8 top of my head what they are exactly.

9 Q. So did CyWee's counsel give you the
10 patents and file wrappers?

11 A. Yes.

12 Q. And they gave you the claim
13 construction materials?

14 A. Uh-huh.

15 Q. And did you find intrinsic evidence?

16 A. Did I find any intrinsic evidence?

17 Q. Like did you -- were you the ones
18 that located the dictionaries and textbooks
19 that are used in this declaration?

20 A. Oh, the -- not the dictionary, but I
21 did the textbook, yes.

22 Q. How many hours did you spend
23 reviewing the materials?

24 A. Somewhere in the range of 15 to 20
25 hours.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. So 15 to 20 hours to review and then
3 18 hours, about, to write?

4 A. Well, I would say probably around 20
5 hours or so to both review and write.

6 MR. CHEN: I'd like to mark this as
7 Exhibit 2.

8 (Exhibit Number 2, Declaration
9 of Joseph J. LaViola, Jr.,
10 Ph.D., dated 2/23/18, was
11 marked for identification.)

12 BY MR. CHEN:

13 Q. Do you recognize this document?

14 A. Yes.

15 Q. Can you tell me what this document
16 is?

17 A. It's a modified declaration on the
18 claim constructions based on Dr. Mercer's
19 declaration.

20 Q. And you signed this declaration on
21 February 23rd of this year; is that right?

22 A. Yes.

23 Q. How many hours did it take you to
24 write this declaration?

25 A. This one was also around maybe 10 to

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 15.

3 Q. And did you review any additional
4 materials to write this declaration?

5 A. The Mercer declaration.

6 Q. So just the Mercer declaration?

7 A. Uh-huh.

8 Q. So when you say 10 to 15 hours, is
9 that inclusive of reviewing the Mercer
10 declaration too?

11 A. No. That would be an additional
12 maybe 10 hours.

13 MR. CHEN: I'd like to mark this as
14 Exhibit 3.

15 (Exhibit Number 3, U.S. Patent
16 Number 8,441,438, was marked
17 for identification.)

18 BY MR. CHEN:

19 Q. Do you recognize this document?

20 A. Yes.

21 Q. What is this document?

22 A. It's the '438 patent.

23 Q. Can you tell me in general terms
24 what the '438 patent discloses.

25 A. In general, it discloses a 3D

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 pointing device and method for compensating
3 movement.

4 Q. What do you mean by "compensating
5 for movement"?

6 A. What I mean is dealing with extra or
7 unnecessary or unwanted movements that occur
8 in the process of moving a device.

9 Q. Can you tell me what you mean by
10 "extra or unnecessary or unwanted movements"?

11 A. Sure. So the device is trying to
12 track orientation, and it's using sensors
13 that sense things other than orientation. So
14 what this tries to do is to mitigate and
15 remove those extraneous measurements.

16 Q. Why don't we start by looking at
17 Claim 1. That starts at Column 18.

18 Can you just read Claim 1 again,
19 refresh your memory, and let me know when
20 you're done.

21 A. (Reviewing document.)

22 Okay.

23 Q. So Claim 1 recites a 3D pointing
24 device, right?

25 A. Yes.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. What is a 3D pointing device?

3 A. 3D pointing device is a device that
4 gathers 3D orientation information to support
5 both direction and/or pointing.

6 Q. Can you tell me what you mean by "to
7 support both direction and/or pointing"?

8 A. So it provides an orientation, and
9 the orientation can be used for pointing,
10 like pointing to something in 3D space, or to
11 be used simply as orientation to provide a
12 direction that the device is currently
13 situated in.

14 Q. So a 3D pointing device -- and I
15 don't want to put words in your mouth, so
16 please correct me if I'm wrong. A 3D
17 pointing device is any device with sensors
18 that can sort of generate its own
19 orientation?

20 A. In general, that is correct.

21 Q. So if I have a device with, say,
22 like a rotation sensor, an accelerometer, and
23 I can figure out the orientation of the
24 device in space based on those sensors in
25 some way, that device is now a 3D pointing

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 device?

3 A. Yeah, it can be considered a 3D
4 pointing device, yes.

5 Q. Does it have to do anything else to
6 be considered a 3D pointing device, or is
7 that the only thing it has to do?

8 A. As long as it can get the
9 orientation information by whatever necessary
10 means, it will be a 3D pointing device.

11 Q. So as long as it can calculate
12 orientation in some way based on the sensors,
13 then it's a 3D pointing device?

14 A. Based on sensors and potentially
15 other software.

16 Q. So, like, based on the sensors and
17 the algorithms that are used to calculate
18 orientation?

19 A. Uh-huh.

20 Q. And 3D pointing devices were
21 well-known at the time of the '438 patent's
22 invention, right?

23 A. Yeah.

24 Q. Then can I direct you to Figures 1
25 and 2.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Yes.

3 Q. So Figures 1 and 2 are just one
4 example of a 3D pointing device, correct?

5 A. Uh-huh.

6 Q. And more specifically, 110 pointing
7 to the --

8 A. Yes.

9 Q. Can you tell me what the difference
10 between a -- in terms of motion, what's the
11 difference between a rigid and nonrigid body?

12 A. In terms of motion, a rigid body
13 will not change its shape. It won't deform,
14 whereas a nonrigid body could potentially
15 deform its shape based on its movement.

16 Q. And when we say "rigid body," that's
17 sort of idealized, right? Like --

18 A. What do you mean by "idealized"?

19 Q. Is there an example where there's a
20 perfectly rigid body?

21 MR. RAFILSON: Objection. Form.

22 Go ahead.

23 THE WITNESS: So I can answer?

24 MR. RAFILSON: Yeah. After I make
25 an objection, you can always answer.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 THE WITNESS: Okay.

3 MR. RAFILSON: Unless I object on
4 the grounds of privilege or I
5 specifically instruct you not to answer.

6 THE WITNESS: Okay.

7 A. So you asked is there anything like
8 a -- what do you have here?

9 BY MR. CHEN:

10 Q. Sorry. Let me --

11 A. As an example of a perfectly rigid
12 body. I would argue that a object that is a
13 rigid body is -- in many cases, would be
14 considered -- if you get onto the anatomic --
15 the atomic level, right --

16 Q. Okay.

17 A. -- then you may argue that no rigid
18 body is perfectly rigid. But that's on the
19 atomic level, which has no bearing on whether
20 or not it would affect the results of the
21 movement of the body or its deformation.

22 Q. So, like, a phone is a rigid body?

23 A. Yeah.

24 Q. And when calculating the effects of
25 motion, what matters? Like, is it the object

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 that you're moving that matters in terms of
3 rigid and nonrigid bodies?

4 MR. RAFILSON: Objection. Compound.

5 Objection. Vague.

6 You can answer.

7 A. Really, it's the material of the
8 object. Okay. If the material is malleable,
9 if you will, then motion could affect its
10 movement. But if it's something strong in
11 terms of its material, like a phone, it would
12 not make any difference in terms of
13 whether -- in terms of it being a rigid body.

14 BY MR. CHEN:

15 Q. What about what is moving the phone
16 in terms of --

17 A. What is moving the phone? Oh,
18 like --

19 Q. If that's a rigid or nonrigid body.

20 MR. RAFILSON: Objection. Vague.

21 A. Whatever is moving the phone does
22 not necessarily have any bearing on whether
23 or not the -- would not make any difference
24 to the calculation of it in terms of whether
25 or not it's rigid or nonrigid.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. CHEN:

3 Q. Well, I guess let me frame it
4 differently.

5 If the object you're moving is rigid
6 but what is affecting that motion is a
7 nonrigid body, is that different from when
8 the object you're moving is rigid but what is
9 affecting that motion is a rigid body?

10 MR. RAFILSON: Objection. Vague.

11 A. It would not necessarily -- so if a
12 nonrigid body interacted with a rigid body,
13 the motion would certainly or could
14 potentially be different if a rigid body was
15 interacting with another rigid body.

16 BY MR. CHEN:

17 Q. How is it different?

18 A. Well, in physics, you have certain
19 laws of collisions, and you have elastic and
20 inelastic collisions. And with an inelastic
21 collision, you make the assumption that the
22 two objects are rigid -- right? -- and
23 there's an equation for that.

24 Then there's elastic collision, and
25 that often has to do with objects that

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 potentially are -- you know, have some sense
3 of give, which could be considered a nonrigid
4 entity, and that might present a different
5 equation for how the collision affects the
6 motion of the body. But that's really only
7 towards collisions.

8 Q. So if I have a rigid body and the
9 motion of that rigid body is being affected
10 by another rigid body, that's one equation?

11 MR. RAFILSON: Objection. Form.

12 A. The -- if it's -- if it's colliding,
13 if there's a collision. Okay? If, for
14 example, another -- if a rigid body or
15 nonrigid body is attached to the -- I mean,
16 already that doesn't make any difference.
17 But if they're colliding, then there is a
18 difference.

19 BY MR. CHEN:

20 Q. So, for example, if my phone is a
21 rigid body and my hand is nonrigid and I put
22 my hand on my phone, there's a collision, and
23 that's different from if it's just like a
24 metal stick and I'm --

25 A. Well --

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 MR. RAFILSON: Objection. Form.

3 A. No, not necessarily. If you're
4 putting your hand on your phone -- okay? --
5 and you're doing it with some amount of
6 force -- okay? -- and that force is
7 significant, there might be a small
8 difference, but it's negligible. Okay?
9 You'd have to take it and smack it across the
10 room. Then you might see a difference.

11 But if I'm just taking the phone and
12 I'm holding it -- right? -- that would be
13 negligible and the difference between whether
14 or not you were -- had a rigid body or a
15 nonrigid body.

16 BY MR. CHEN:

17 Q. So you're saying the difference is
18 only significant if the force being affected
19 is very significant?

20 A. If the force is significant enough.

21 Q. What do you mean by "significant
22 enough"?

23 A. I mean, there's going to be a
24 certain threshold where the force would make
25 a difference. I can't tell you what that is.

JOSEPH J. LAVIOLA, JR., Ph.D.

Depends on the material.

Q. In all other cases when you're moving a rigid body, it doesn't matter what's affecting the force, whether that's rigid or nonrigid?

MR. RAFILSON: Objection. Form.

A. Could you rephrase that question?

BY MR. CHEN:

Q. Sure.

So for motion, in cases where I'm moving a rigid body, the only place that matters is when there's a really significant force, what's affecting the force is significant. That's the only place -- the difference between a rigid and nonrigid body matters, in terms of what's affecting the rigid body?

A. In terms of what's affecting --

MR. RAFILSON: Objection. Form.

Misstates testimony.

You can answer.

A. Okay. So you're asking me that the only thing that affects the motion of a rigid body when a nonrigid body is attached to it

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 is the amount of force that would be applied
3 from the nonrigid body to the rigid body?

4 BY MR. CHEN:

5 Q. I guess I'm trying to figure out the
6 differences when a rigid body is affecting a
7 force on a rigid body and a nonrigid body is
8 affecting a force on a rigid body.

9 And, again, please correct me, but
10 it seems to me that you were saying that it
11 only makes a difference because of
12 elasticity, and that only makes a difference
13 when the force is very significant.

14 A. It -- it only makes a difference if
15 the force is significant enough related to
16 the properties of -- the physical properties
17 of the object that is nonrigid.

18 Q. So --

19 A. I could have an object that is, you
20 know, like a balloon or something or one of
21 those -- you know those balls you hold in
22 your hands to squeeze, right?

23 Q. Like a stress ball?

24 A. Yeah. Well, that's fairly
25 malleable, and, you know -- and you can

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 squeeze it and it'll move and change its
3 shape, right?

4 Then you can have something like a
5 tennis ball, which is somewhat harder; and
6 you can still squeeze it, but it takes more
7 force to do so. Right?

8 So depending on the object itself
9 that is nonrigid, it will affect how much
10 force you need to apply to change its shape.

11 Q. But just in terms of, like, moving
12 an object from Point A -- say, like the front
13 of this table to the end of this table, it
14 doesn't matter -- well, let me ask you, does
15 it matter -- if I have a phone that's on the
16 front of this table and I just push it to the
17 end of this table, does it matter if what's
18 pushing it is a rigid body or a nonrigid
19 body?

20 MR. RAFILSON: Objection. Form.

21 A. It only matters if -- it could
22 matter, depending on a number of factors. So
23 if I have a phone and I push it across the
24 table, one end to the other -- right? -- or
25 it's being pushed by an object and that

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 object is nonrigid, depending on the object,
3 it could affect the motion of the rigid body.
4 But there's lots of variables that would come
5 into play.

6 BY MR. CHEN:

7 Q. But -- are you okay?

8 A. Yeah, I'm fine.

9 Q. But whether the object that is
10 pushing the phone is rigid or nonrigid is a
11 factor that you have to take into account?

12 MR. RAFILSON: Objection. Form.

13 A. If -- if there was an object -- such
14 an object that was rigid or nonrigid and you
15 were, you know, requiring enough force to
16 push a phone from one end of the table to the
17 other, there would be -- the calculations
18 would be different in calculating the
19 collision and the responsive force.

20 BY MR. CHEN:

21 Q. Okay. I just want to run a
22 real-world example by you just to make sure
23 I've got the concept right.

24 A. Okay.

25 Q. So, like, a steel bar is a rigid

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 body?

3 A. Yes.

4 Q. And, like, a phone is also a rigid
5 body?

6 A. Uh-huh.

7 Q. They're both made of metal --

8 A. Yeah.

9 Q. -- essentially. So if the force
10 that's affecting the phone and pushing it
11 from one end of this table to the other is
12 that steel bar, that's different than if I
13 just use my arm and I go like -- I push it?

14 A. The force isn't different. It would
15 be the amount of force that would be needed.
16 So given a rigid body such as a steel bar and
17 you were to hit a phone and move it across
18 the table versus using your hand, there may
19 be a difference in the amount of force needed
20 to move the phone in the same -- the same
21 distance.

22 Q. Is that the only difference, just
23 the amount of force?

24 MR. RAFILSON: Objection. Form.

25 A. At the end of the day, yeah.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. CHEN:

3 Q. Does it matter how complex the
4 movement is? Let me just give you an
5 example.

6 Like, if it's a steel bar, it's sort
7 of just one point of contact. But if it's,
8 like, my arm, it's sort of my elbow and my
9 wrist, and they're all kind of moving at the
10 same time to affect that force, does that
11 make a difference?

12 MR. RAFILSON: Objection. Form.

13 A. No, not really.

14 BY MR. CHEN:

15 Q. Why doesn't it make a difference?

16 A. Because it's still a force that's
17 being applied to the object. You may need to
18 calculate that force a little differently
19 because of -- you have, you know, different
20 moving parts, but it's still a force that is
21 being calculated and acting on the object
22 that is moving.

23 Q. Well, let's focus on the
24 calculations. How are the calculations
25 different?

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. So you would have to -- so what
3 you're effectively talking about with, for
4 example, an arm is, there are degrees of
5 freedom related to that particular object.
6 Right? So I've got an elbow, so there's a
7 degree of freedom there, a wrist, fingers.
8 And if I was to get a correct calculation of
9 the force, I would have to understand what
10 the forces were that were emanating related
11 to the elbow, the wrist, and the fingers. So
12 it would be a more complex calculation --
13 right? -- if I was to want to give a truly
14 accurate force that was being applied.

15 Q. And that's a different calculation
16 than just a steel bar? Like, the steel bar
17 is sort of a simpler calculation?

18 A. It's not necessarily a different
19 calculation; it's a more complex calculation
20 using the same principles.

21 Q. Because there's more to take into
22 account because there's degrees of freedom in
23 the wrist?

24 A. Yeah. I mean, the laws of physics
25 are the laws of physics.

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2 Q. So these calculations when the -- so
3 when you're saying the force is the same when
4 the object is being affected by a rigid
5 versus nonrigid body, the force is the same,
6 but the calculations are a little different;
7 is that right?

8 MR. RAFILSON: Objection. Vague.

9 A. The calculations would be modified
10 to reflect the -- well, it depends. If
11 you're talking about minute details about the
12 force, the calculations might be different.
13 If you're talking about, you know -- it
14 really depends on the level of accuracy that
15 you want to have with the forces that you're
16 trying to calculate.

17 So on the one hand, if you're trying
18 to be very accurate, extremely accurate, then
19 you would have to take into account some of
20 these other forces that relate to the object
21 that's pushing it. But if you're just trying
22 to, you know, get a general representation of
23 the force that's moving, you know, those
24 could be neg- -- I can't say that word --
25 negligible.

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2 And it turns out, actually, that,
3 from the rigid body's perspective, it doesn't
4 really make that much of a difference because
5 the sensor is in the object that's being
6 moved. So it's just going to sense force.
7 Doesn't really care where it comes from.

8 BY MR. CHEN:

9 Q. From the rigid body's perspective --

10 A. Yes.

11 Q. -- but the calculations that you
12 have to do to --

13 A. So if I was to calculate the forces
14 of the object that was moving, that was
15 pushing the other object, then there would be
16 some subtleties in how I would do that. If
17 I'm calculating the forces or the
18 accelerations, for example, which are really
19 just forces, from the rigid body's point of
20 view that's being moved, it doesn't really
21 make any difference how that movement is
22 going to measure the force and take that into
23 account as a part of whatever it's doing for
24 calculating the motion of that body.

25 Q. Are you talking sort of about the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 magnitude and force or --

3 A. Well, magnitude and direction.

4 Q. Why doesn't it matter in terms of
5 direction?

6 A. Because the -- if this is my rigid
7 body -- okay? -- and I have sensors in it
8 that are going to measure, for example,
9 forces acting on it -- right? -- it's going
10 to be measured forces from whatever, you
11 know, direction. It doesn't -- there's no
12 relevance to how those forces are being
13 calculated on the object. It's just going to
14 sense the forces that are acting on it. If
15 you're talking about trying to calculate the
16 force -- the forces of the object that is
17 actually moving the body, that's different.

18 Q. So in terms of the rigid object that
19 has sensors on it, it doesn't know what
20 object is affecting that force?

21 A. Doesn't matter -- the force or any
22 other -- well, the object will measure
23 whatever quantities that are -- that the
24 sensors in it support.

25 Q. So it just comes up with a value

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 regardless of what object is affecting that
3 force?

4 A. Yes.

5 Q. And that value tells you nothing
6 about whether the object affecting that force
7 was rigid or nonrigid?

8 A. That's right.

9 Q. And it doesn't tell you anything
10 about -- for example, if my arm was affecting
11 that force, it doesn't tell you anything
12 about my wrist or my elbow or my shoulder and
13 all those components that affect that force?

14 A. No.

15 Q. It's just a value that comes up in
16 the sensor?

17 A. Uh-huh.

18 Q. Turn back to Claim 1. I want to get
19 a sense of the process flow of this claim, if
20 that makes sense.

21 A. Yeah.

22 Q. So you have a 3D pointing device
23 that has a housing. There is a printed
24 circuit board enclosed by that housing.
25 What's attached to that housing is a six-axis

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 sensor?

3 A. It's not attached to the housing;
4 it's attached to the printed circuit board.

5 Q. Right. Attached to the printed
6 circuit board.

7 And that has a rotation sensor that
8 detects angular velocities, and it also has
9 an accelerometer for detecting axial
10 accelerations; is that right?

11 MR. RAFILSON: Objection. Compound.
12 Objection. Document speaks for itself.

13 You can answer.

14 A. Yeah, that's what it says in the
15 claim.

16 BY MR. CHEN:

17 Q. And rotation sensors were in the
18 prior art at the time of the invention of the
19 '438 patent; is that correct?

20 A. Uh-huh.

21 Q. And so were accelerometers; is that
22 correct?

23 A. Yes.

24 Q. And if you turn to the next page on
25 Column 19, it talks about how these first and

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 second signal sets, the first being from the
3 rotation sensor and the second being from the
4 accelerometer or transmitter -- do you see
5 that?

6 A. Yes.

7 Q. And then it talks about how you
8 "calculate a resulting deviation comprising
9 resultant angles in said spatial pointer
10 reference frame by utilizing a comparison to
11 compare the first signal set with the second
12 signal set."?

13 Do you see that?

14 A. Yes.

15 Q. What does it mean, "to utilize a
16 comparison to compare the first signal set
17 with the second signal set"?

18 A. Well, what it effectively means is
19 that you are examining those two signal sets
20 and using them to compute deviation angles.

21 Q. What do you mean by "examining"?

22 A. By looking at those two signal sets
23 and comparing them. In this particular case,
24 in regards to the patent, we're comparing
25 them using a -- what is known as "enhanced

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 comparison method."

3 Q. Why do you have to use that? Is it
4 because axial acceleration and angular
5 velocities are common units, so you have to
6 use an enhanced comparison method?

7 MR. RAFILSON: Objection. Form.

8 A. You use it for that reason and also
9 because both of those sensors have noise and
10 errors associated with them.

11 BY MR. CHEN:

12 Q. So what enhanced comparison method
13 does the '438 patent disclose?

14 THE WITNESS: Do you want me to --

15 MR. RAFILSON: You -- of course you
16 can answer.

17 A. Yeah. I mean, it's in my
18 declaration here. The enhanced comparison
19 method is actually a -- can be construed as
20 an extended Kalman filter, which is described
21 in Equations 5 through 11 in the patent.

22 BY MR. CHEN:

23 Q. Does Claim 1 state "Kalman filter"
24 anywhere in the claim?

25 A. No, does not.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. Does it state "extended Kalman
3 filter"?

4 A. No.

5 Q. Does the '438 patent use the words
6 "Kalman filter"?

7 A. It does not, but it uses equations
8 that are the equations of an extended Kalman
9 filter and says that those equations are used
10 as part of the enhanced comparison method.

11 Q. It doesn't ever use the words
12 "Kalman filter"?

13 A. It does not use the words.

14 Q. It never uses the words "extended
15 Kalman filter"?

16 A. No.

17 Q. So is Equations 5 through 11 the
18 disclosure of the extended Kalman filter in
19 the '438 patent?

20 A. What do you mean by "disclosure"?

21 Q. Is there anywhere else in the patent
22 other than Equations 5 through 11 --

23 A. That --

24 Q. -- that disclose an extended Kalman
25 filter?

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Yeah, that's the only place in the
3 patent that actually provides those equations
4 which represent an extended Kalman filter.

5 Q. So Equations 5 through 11 are the
6 only place in the patent that tell you how to
7 do the enhanced comparison method?

8 MR. RAFILSON: Objection. Misstates
9 testimony.

10 A. Actually, the enhanced comparison
11 method requires not just Equations 5 through
12 11 but, actually, at a minimum, requires
13 Equations 1, 2, 3, and 4.

14 BY MR. CHEN:

15 Q. So, at a minimum, what are all the
16 equations that are required to do --

17 A. At a minimum, 1 through 11.

18 Q. Is there anything else that's
19 required to do the extended Kalman filter?

20 A. There are -- as I stated in my
21 declaration, there are things in the -- that
22 anybody of ordinary skill in the art who
23 understand the extended Kalman filter would
24 know that are not explicitly described in
25 the -- in the patent in Equations 5

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2 through -- 1 through 11.

3 Q. So are those things -- I guess what
4 are those things that a person would know?

5 A. For example, how to set up the
6 measurement noise, how to set up the process
7 noise, how to initialize the filter or the
8 method, how to represent the process in the
9 measurement models.

10 Q. So are these specific equations or
11 just setup variables?

12 A. Yeah. Yeah. The extended Kalman
13 filter is a general framework. So there is
14 -- anyone of ordinary skill in the art would
15 understand that it is a general framework,
16 and, therefore, there are lots of ways to set
17 it up.

18 Q. And Kalman filters were well-known
19 in the art at the time of the --

20 A. Yes.

21 Q. -- invention of the '438 patent,
22 correct?

23 A. Yeah.

24 Q. And so were extended Kalman filters?

25 A. Uh-huh.

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MR. CHEN: Do you want to take a quick --

MR. RAFILSON: Sure. Yeah.

MR. CHEN: -- ten-minute break?

MR. RAFILSON: Sure.

(Break taken from 9:06 a.m. to 9:18 a.m.)

BY MR. CHEN:

Q. Look back at Exhibit 3, which is the '438 patent, and let's take a look at Claims 14 and 19 now. It's the very last page. Take a look at those, and tell me when you're done.

A. (Reviewing document.)

Okay.

Q. So Claims 14 and 19 are identical to each other; is that right?

MR. RAFILSON: Objection. Form.

Objection. The document speaks for itself.

A. On initial reading of it just now, they look very similar.

BY MR. CHEN:

Q. Okay. So let's just take Claim 14

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2 to be representative. So Claim 14, like
3 Claim 1, also talks about obtaining a set of
4 angular velocities; is that right?

5 A. Yeah.

6 Q. And like Claim 1, it also talks
7 about obtaining a set of measured axial
8 accelerations?

9 A. Uh-huh.

10 Q. What is different, though, is that
11 it talks about calculating predicted axial
12 accelerations based on measured angular
13 velocities?

14 A. Uh-huh.

15 Q. How do you calculate a predicted
16 axial acceleration?

17 MR. RAFILSON: Objection. Form.

18 A. You calculate it -- it's actually in
19 the patent. If you go to Column 12 -- and
20 Column 12 takes -- if you go to Equation 1,
21 it shows how you take the angular velocities
22 to calculate the -- what is called -- known
23 as the second quaternion in the patent, and
24 that quaternion is then used in Equations 2,
25 3, and 4 to compute to predicted axial

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 accelerations.

3 BY MR. CHEN:

4 Q. Can you run through how this
5 equation works? Let's start with Equation 1.

6 A. So Equation 1 starts off with --
7 this is the standard equation, differential
8 equation, for a -- the propagation of a
9 quaternion through time. Okay? And angular
10 velocity represents the derivative of
11 orientation. Okay? So we're taking
12 derivative of orientation, angular velocity,
13 and multiplying it by the initial quaternion,
14 and that is going to give you an updated
15 quaternion. Okay?

16 If you -- and then once you have
17 that, then you can use the various components
18 of the quaternions, the new quaternion that
19 you calculated, to compute the individual
20 components of the axial accelerations.

21 Q. So let me just step back. What's a
22 quaternion?

23 A. A quaternion is a representation for
24 orientation that's comprised of four numbers.
25 The four numbers include a vector,

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 three-dimensional vector, and a scale of
3 value to represent an axis and angle.

4 Q. So what do -- what do converting
5 values into quaternion format allow you to
6 do?

7 MR. RAFILSON: Objection. Form.

8 A. They provide a different
9 representation that is somewhat easier to
10 work with under various -- under different
11 circumstances.

12 BY MR. CHEN:

13 Q. Can you give me some examples of why
14 it's easier?

15 A. They're easier to use in the context
16 of matrix vector notation, which is common
17 notation, and tools used in the enhanced
18 comparison method that was described here.
19 They also help to deal with ambiguities that
20 you find in Euler angles, E-U-L-E-R.

21 Q. What is matrix vector notation?

22 A. Matrix vector notation is just a
23 notation that is often used where a matrix is
24 a sequence of numbers in -- typically, a
25 two-dimensional column, and a vector is often

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 a one-dimensional column with numbers, and
3 you can multiply them together to do various
4 things.

5 Q. So --

6 A. You can multiply, add, and subtract,
7 various, you know, mathematical things that
8 you can do with them.

9 Q. So it's sort of a notation, just
10 allows you to do basic mathematical
11 calculations?

12 A. Linear-algebra-type mathematics,
13 among other things.

14 Q. So you said quaternions deal with
15 ambiguities. What kind of ambiguities are
16 you talking about?

17 A. So Euler angles, for example, go
18 from zero to 360. Zero and 360 are the same
19 value, orientation. So, you know, there's
20 ambiguity there. Quaternions allow you to
21 circumvent that ambiguity by putting it into
22 a form that simply just provides an axis and
23 an angle.

24 Q. In terms of just orientation, are
25 there any other ambiguities that quaternions

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2 allow you to take care of?

3 A. That's the principal one.

4 Q. Are there secondary ones?

5 A. No. Off the top of my head, I would
6 say that's -- if there are, they're not very
7 common. I'm not aware of them. The primary
8 reason you do this is because of the
9 ambiguities with the nonlinearities of the
10 Euler angles.

11 THE REPORTER: I'm sorry. The
12 ambiguities of the --

13 THE WITNESS: Of the Euler angle
14 representation.

15 BY MR. CHEN:

16 Q. So the principal reason you use
17 quaternions is to deal with the zero-to-360
18 ambiguity of the Euler angles?

19 MR. RAFILSON: Objection. Form.

20 A. Yeah, that's one of the primary
21 reasons. It also makes it easier to do
22 things like interpolation between
23 orientations.

24 BY MR. CHEN:

25 Q. Can you tell me what you mean by

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 "interpolation between orientations"?

3 A. So I'm given two orientations, and I
4 want to try to figure out an orientation in
5 between them, you can use -- quaternions can
6 make it somewhat easier to deal with that
7 from a mathematical standpoint.

8 Q. Can you give me an example of two
9 different orientations and how you would
10 interpolate?

11 A. Sure. Let's say I have an
12 orientation along some arbitrary axis in
13 space -- okay? -- and there's a rotation
14 about that axis by 30 degrees, let's say, and
15 I have another orientation about another
16 arbitrary axis by 40 degrees and I want to
17 try to understand, for example, how to go
18 from that orientation to the second
19 orientation or I want to try to find an
20 orientation in between them, quaternions make
21 it easier to do that.

22 Q. So besides the zero-to-360 ambiguity
23 and the interpolation between rotations, is
24 there another reason or another ambiguity
25 that quaternions address?

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2 MR. RAFILSON: Objection. Form.

3 Objection. Asked and answered.

4 You can answer.

5 A. Yeah. No. That's the main reason.

6 BY MR. CHEN:

7 Q. And quaternions are in the prior art
8 at the time of the invention of the '438
9 patent; is that correct?

10 A. Yes.

11 Q. So stepping forward again to the --
12 calculating the predicted axial
13 accelerations. So the first step is the
14 first quaternion; is that correct?

15 A. No. Well, yes. You take the first
16 quaternion, which is the prior quaternion,
17 and you use that in combination with the
18 angular velocity to calculate second
19 quaternion.

20 Q. So what is the first quaternion?

21 A. The first quaternion is -- if you
22 look at the patent, Figure 7, you'll see --
23 and number 710, the first quaternion is
24 actually the quaternion from the previous
25 state of the system or potentially the

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2 initial -- initialized value that you use
3 when you start the filter or the comparison
4 method.

5 So that's what the first quaternion
6 is. It's from the previous state of the
7 system.

8 Q. Okay. When you say "previous
9 state," what do you mean by the "state of the
10 system"? What is the state of the system?

11 A. The "state" is a term that's used to
12 describe where the current process is. So,
13 like, in this particular algorithm, we've got
14 different moments in time that we're talking
15 about, and the state represents a particular
16 point in time.

17 Q. So where the process is at that
18 particular point in time?

19 A. It's sort of where it would be
20 considered what -- you know, where the
21 algorithm or the method is at some point in
22 time. So at time T-1, as you can see from
23 the patent, is considered to be the previous
24 state -- right? -- which is really, you know,
25 just -- which is what -- this is a recursive

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 routine.

3 Q. Right.

4 A. So it takes information after it's
5 done and reuses it, and the previous state in
6 this case is the information that is reusing.

7 Q. So it's sort of the -- as I
8 understand recursion, it is the final result.
9 You go through the process and you get an
10 output, and then you put that output back in
11 as the initial value set, and it just
12 recursively keeps going and going and going?

13 A. Yeah. It uses the output of the
14 algorithm as input to the algorithm on the
15 next iteration of the loop.

16 Q. So this previous state is either
17 a -- some initial value that you set or the
18 final output from the first run or second run
19 or some run?

20 A. Yeah.

21 MR. RAFILSON: Objection. Form.

22 BY MR. CHEN:

23 Q. So what would that output from the
24 first run be that you were putting back in as
25 the initial value?

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2 A. It would be known as the third
3 quaternion, which you see in 735, which is
4 the quaternion that's generated by comparing
5 the current state with the measured state.

6 Q. So what does this third quaternion
7 represent?

8 A. The third quaternion represents the
9 current orientation of the device.

10 Q. And then because the algorithm is
11 recursive, you plug in the current
12 orientation of the device as the initial
13 value set, and you just run it --

14 A. Well, it's not necessarily -- you
15 don't plug it in as the initial value set.
16 The initial value set is the first thing you
17 give it when you start.

18 Q. Right.

19 A. Okay? What you're doing is you
20 just -- you're taking it and you're feeding
21 it in as the input to the filter after it
22 starts running.

23 Q. So let's say I have put in the
24 initial value set. I've run it once.

25 A. Yep.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. Then I have that current
3 orientation, which is the third quaternion.
4 Then I just put it back in as my first
5 quaternion?

6 A. Yes.

7 Q. So that first quaternion is the
8 orientation of my device after I've run
9 through the algorithm once?

10 A. Yes.

11 Q. And then how do I use that to --
12 into Equation 1? Is that what you said?

13 A. Yes. Yeah, that -- if you go to
14 Equation 1, that ends up being the quaternion
15 at the previous state -- right? -- in time
16 and then we have a current measurement of
17 angular velocity. If you take those two and
18 combine them together, you're going to get a
19 estimated quaternion, which would be the --
20 one of the estimates that you would get as
21 part of the algorithm of the orientation of
22 the device.

23 Q. And that estimated quaternion is the
24 second quaternion?

25 A. Yes.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. How do you combine them together?

3 A. Combine what together?

4 Q. The first quaternion and the current
5 measurement of angular velocity.

6 MR. RAFILSON: Objection. Form.

7 A. Well, you can see from Equation 1
8 that they're combined based on the
9 quaternion -- the first initial quaternion,
10 quaternion one is put into a vector notation.
11 The angular velocity is put in the matrix
12 notation, and then you -- if you multiply
13 them together and divide by two, according to
14 the differential equations, it describes
15 quaternions through time; you can get the
16 second quaternion.

17 BY MR. CHEN:

18 Q. Okay. So I just want to make sure I
19 got that right. So right side, q_0 , q_1 , q_2 ,
20 q_3 . Which quaternion is that?

21 A. That is the first quaternion.

22 Q. And then I have one-half, and
23 these -- the next part of the -- those are
24 the angular velocities?

25 A. Yes, in that matrix.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. In the matrix vector notation?

3 A. This is a matrix vector notation,
4 yes.

5 Q. And then I'm multiplying that by
6 one-half, and I'm solving for the next, which
7 is q_0 , q_1 , q_2 , q_3 , and that's the second
8 quaternion?

9 A. Yes.

10 Q. So I'm solving for the very right
11 side of that equation?

12 A. No. You're solving for the left
13 side of the equation. The left side of the
14 equation, the $Q \cdot Q$ -- q_0 through q_4 --
15 through q_3 , and there are dots on top of
16 them, that indicates that that's actually
17 the -- that represents the second quaternion.

18 Q. Okay. So I think I got you. So the
19 very left side of the equation, which is q_0
20 dot, q_1 dot, q_2 dot, q_3 dot, that is the
21 second quaternion that you're solving for?

22 A. That's what you're calculating.

23 Q. Okay. And then that's calculated by
24 one-half times the first quaternion times
25 these angular velocities and matrix vector

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 notation?

3 A. Yes.

4 Q. And that gives you an estimated
5 orientation at a new point in time?

6 A. Yes.

7 Q. And that's the second quaternion?

8 A. Yes.

9 MR. RAFILSON: Counsel, I'd just
10 like to note that there appears to be an
11 issue with the -- the '438 patent, it
12 appears to be generally fine, but some
13 of the -- some of the digits appear to
14 be filled in for some reason. I don't
15 know that it makes a substantive
16 difference, but I just wanted to have
17 that on the record.

18 MR. CHEN: Yeah. I think it's
19 probably just a printing issue.

20 BY MR. CHEN:

21 Q. So now that I have my second
22 quaternion, which is an estimated orientation
23 at a new point in time, I can use the
24 Equations 2, 3, and 4 to calculate a
25 predicted acceleration?

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Yes.

3 Q. So Equation 2 is a calculation of a
4 predicted acceleration along the x-axis?

5 A. Yes.

6 Q. And then Equation 3 is the predicted
7 calculation acceleration along the y-axis?

8 A. Uh-huh.

9 Q. And then Equation 4 is a prediction
10 of -- predicted acceleration along the
11 z-axis?

12 A. Yes.

13 Q. Is what we've been talking about,
14 are those well-known concepts, or were they
15 well-known concepts at the time of the
16 invention of the '438 patent?

17 MR. RAFILSON: Objection. Form.

18 A. The standard equations for -- the
19 differential equation for the quaternion and
20 the equations for computing these predicting
21 accelerations are fairly well-known in the
22 field.

23 BY MR. CHEN:

24 Q. So Equation 2 would have been
25 well-known in the art at the time of the '438

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 patent's invention?

3 MR. RAFILSON: Objection. Form.

4 A. Uh-huh.

5 BY MR. CHEN:

6 Q. And Equation 3 would have been
7 well-known in the art at the time of the
8 invention of the '438 patent?

9 MR. RAFILSON: Objection. Form.

10 A. Uh-huh.

11 BY MR. CHEN:

12 Q. And Equation 4 would have been
13 well-known in the art at the time of the
14 invention of the '438 patent?

15 MR. RAFILSON: Objection. Form.

16 A. (Nods head.)

17 BY MR. CHEN:

18 Q. Is there any other way that the '438
19 patent discloses how to calculate a predicted
20 acceleration?

21 MR. RAFILSON: Objection. Form.

22 A. This represents one potential way to
23 do it. There may be others, but I'm not
24 aware of them.

25 ///

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. CHEN:

3 Q. Does the '438 patent disclose any
4 other potential ways of calculating the
5 predicted acceleration?

6 MR. RAFILSON: Objection. Form.

7 A. No, not that I'm aware of.

8 BY MR. CHEN:

9 Q. Let's go back to Claim 14, if you
10 will. And, again, just for the record, we're
11 using Claim 14 as being representative of
12 Claim 19 as well.

13 The very lines -- Column 21, lines
14 33 to 38, it says, "Comparing the second
15 quaternion in relation to the measured
16 angular velocities . . . of the current state
17 at current time T with the measured axial
18 accelerations . . . and the predicted axial
19 accelerations . . . also at current time T."

20 A. Yes.

21 Q. How does the '438 patent disclose
22 doing this comparison?

23 A. So it discloses it in a number of
24 ways. First, if you go to the patent,
25 Figures 7 and 8, it shows the process by

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 which 735 -- it shows how it gets the second
3 quaternion, the measured axial acceleration
4 and the predicted axial acceleration, and
5 then it shows that you compare the two to
6 create a third quaternion. Both 7 and 8 do
7 that.

8 The patent also mentions how to do
9 this, basically, through Columns 12, 13, and
10 14, which describe the whole process of going
11 from the first quaternion to the second
12 quaternion, to the measured angle
13 acceleration, predicted axial accelerations,
14 and then combining them together through
15 Equations 5 through 11 to get the updated
16 quaternion.

17 Q. So in terms of the actual
18 calculations that you would use, which
19 equations would those be?

20 A. The actual equations? Turns out
21 it's going to be -- the actual equation that
22 will do the comparison is Equation 11.

23 Q. Is this part of the extended Kalman
24 filter that you were talking about?

25 A. Yes.

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2 Q. So Equations 1 through 4 are sort of
3 my process for getting current state and
4 predicted accelerations, and then Equations 5
5 through 11 are the Kalman filter?

6 A. Okay. So Equations 1 through 4 and
7 the measured acceleration are going to give
8 you the quaternion, the measured
9 acceleration, and predicted acceleration.
10 And those -- that piece right there will give
11 you data that is necessary to put into
12 Equations 5 through 11, which are the basic
13 equations of the extended Kalman filter.
14 Okay? They're not the only equations --
15 right? -- because, remember, I said extended
16 Kalman filters are framework, so there are
17 other pieces that are associated with it.
18 Those pieces are being able to get the
19 appropriate data that you need to put into
20 the filter. Okay? Those pieces happen to be
21 Equations 1 through 4 and the measured axial
22 acceleration.

23 So those pieces, then, can be put
24 into the, quote/unquote, main equations of
25 the extended Kalman filter to get the

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2 comparison and to calculate the third
3 quaternion, which essentially fuses all of
4 these information together.

5 Q. And that main equation is 5 through
6 11?

7 A. Yeah. Standard --

8 Q. And that's just a framework?

9 A. Yes.

10 Q. So I think earlier you testified
11 that Kalman filters reduce uncertainty and
12 they deal -- they deal with noise; is that
13 right?

14 A. Yes, that's right. That's one of
15 the things they do.

16 Q. What other things do they do?

17 A. Well, they do sensor fusion.

18 Q. What do you mean by "sensor fusion"?

19 A. What I mean by "sensor fusion" is
20 that -- well, they have the ability to take
21 data from multiple sensors and combine them
22 together in such a way to get the most
23 information possible and the best estimates
24 possible out of that data.

25 Q. Can you explain to me how a Kalman

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2 filter does that.

3 MR. RAFILSON: Objection. Form.

4 A. So if you go to my declaration, I
5 actually describe this. Let me find the
6 appropriate paragraph. 42.

7 BY MR. CHEN:

8 Q. And just for the record, are you
9 looking at your --

10 A. Oh, I'm looking at the --

11 Q. Exhibit?

12 A. Exhibit 2.

13 Q. Okay.

14 A. Yeah. 43, Exhibit 2.

15 So what I say here in my declaration
16 is a description of how the filter actually
17 works. Right? Then I'll read it here. So
18 the extended Kalman filter -- we're talking
19 about the extended Kalman filter but not the
20 Kalman filter because they are similar but
21 are different.

22 Q. So let's step back a little bit.
23 What is the difference between an extended
24 Kalman filter and Kalman filter?

25 A. The main difference between the

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2 Kalman filter and the extended Kalman filter
3 is the Kalman filter is designed to work only
4 with things that are linear. It cannot
5 handle nonlinearities in the data.

6 The extended Kalman filter overcomes
7 this so that you can use it to do things like
8 orientation, and it does this by simply
9 linearizing the nonlinear functions and
10 states that are part of -- that you put into
11 the filter.

12 And it does that by taking the
13 Jacobian of the matrix that is defined or
14 that you define that represents the
15 fundamental equations that are used to
16 describe the process model and measurements
17 that you're taking.

18 And it turns out -- actually, if you
19 go back to the '438 patent and you look at
20 Equations 6 and 10, you will see -- actually,
21 there is no numbering for the first equation
22 above 6. So I don't know why that is, but if
23 you look at the equation beginning with
24 capital F sub X, capital F sub U, those
25 equations are actually the Jacobians that are

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2 used to linearize the process model, and
3 Equation 10 represents the Jacobian for the
4 function that you describes the measurement
5 model. Now, I haven't described to you what
6 the process model and measurement model are.
7 I will do that now.

8 So in our extended Kalman filter,
9 what we have is an underlying process model
10 which is designed to estimate what it is that
11 you're trying to find. Okay? And then
12 there's a measurement model, which,
13 basically, is a model of the sensors or
14 whatever you want to put in it that will --
15 that gives you data about the world, the
16 sensors.

17 And then what this does is it
18 combines the two together using a
19 probabilistic approach. So it uses a thing
20 known as a "predictor-corrector mechanism,"
21 so it predicts what the states should be and
22 then uses the measurement data to correct,
23 and it does this by effectively weighting the
24 two values or states.

25 So you've got the information from

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2 the process model and information from the
3 measurement model, and then using covariance
4 matrices, which are defined in Equations 5
5 through 11, it tells you the variability or
6 how certain you are of how much you trust the
7 process model or how much you trust the
8 measurement model. And the equations then
9 will actually figure out, optimally, based on
10 those covariances, which model to trust more,
11 and it assigns, effectively, a weight to
12 them.

13 So when the filter runs, sometimes
14 it will say, "I think my process model is
15 doing better, so I'm going to give it more
16 weight." Sometimes it will say, "Oh, the
17 measurement model is doing better. The
18 measurements I'm getting are better. I'm
19 going to give that more weight." And it does
20 this repeatedly, recursively, as the new data
21 comes in and as the new process model is
22 calculated.

23 Q. So it weighs the estimate model?

24 MR. RAFILSON: Objection. Form.

25 ///

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2 BY MR. CHEN:

3 Q. I'm sorry. It assigns some
4 weight --

5 A. It does.

6 Q. -- to the estimate model?

7 MR. RAFILSON: Objection. Form.

8 A. It assigns weight to the estimate in
9 two different places. Okay? You're getting
10 two estimates, effectively. Right? You're
11 getting the estimate from your process model
12 and you're getting your estimate from your
13 measurement model, and it assigns a weight to
14 both of them.

15 BY MR. CHEN:

16 Q. Step back for one second. And what
17 is linear versus nonlinear data?

18 A. Example would be position data, like
19 X, Y, Z, you know, a position in space that
20 would be considered linear because it -- it
21 obeys the laws of vector space. In other
22 words, it doesn't repeat itself as opposed to
23 orientations.

24 Remember I said that zero and 360
25 are the same? Well, that is a nonlinear

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2 data, or nonlinear process, if you will, or
3 number. That's why the original Kalman
4 filter doesn't handle that, because it can't
5 deal with the fact that it repeats itself --

6 Q. Okay.

7 A. -- or that zero and 360 are the same
8 value.

9 Q. And that's why you use an extended
10 Kalman filter --

11 A. Yes.

12 Q. -- when calculating orientation?

13 A. Yes, in this case. It's not the
14 only way to do it, but . . .

15 Q. But the '438 patent says, "How I'm
16 going to deal with this problem is, I'm going
17 to use an extended Kalman filter"?

18 A. In this particular embodiment.

19 Q. What other embodiments are there in
20 the '438 patent?

21 A. Well, I mean, this '438 patent says
22 there are potentially other embodiments that
23 you could use. This is just one.

24 Q. But are there any other --

25 A. Are there any other ways to do this?

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2 Q. Are there any other implementations
3 specifically disclosed in the '438 patent?

4 A. No.

5 MR. RAFILSON: I think we've been
6 going for about an hour. If you want to
7 break at some point in the near future,
8 that would be good for the witness.

9 MR. CHEN: Yeah. Let's take a
10 ten-minute break.

11 MR. RAFILSON: Sure.

12 (Break taken from 10:02 a.m. to
13 10:17 a.m.)

14 BY MR. CHEN:

15 Q. Before the break, we were talking
16 about the extended Kalman filter. And there
17 was a lot of information, so I just want to
18 make sure I got it right.

19 So you have the process model, which
20 is what you're trying to find out; is that
21 right?

22 A. No. Well, yes and no. Okay. So
23 the Kalman filter itself, what you're trying
24 to do with it is to try to find the best
25 estimate that you can of -- for a particular

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2 phenomenon, whatever it might be. In this
3 case, orientation.

4 So the way that it works is, the
5 process model is a method by which the filter
6 uses for you to predict what that orientation
7 is going to be based on your understanding of
8 the world. Okay? Most of the time, it's
9 governed by a differential equation. That's
10 what this is -- this equation here,
11 Equation 1, is a differential equation.
12 Differential equations describe things
13 through time -- or they describe things
14 through space, but they also describe things
15 through time.

16 So that is one part of the overall
17 process of getting our estimate. The
18 measurement model is also another way to get
19 the estimate. So what you're really doing is
20 getting two estimates, and then you're
21 combining them together by determining which
22 one has more weight than the other at any
23 given time.

24 Q. And the measurement -- the
25 measurement model is based on the sensors?

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2 A. It doesn't have to be, but very
3 often it is. You can put -- like I said,
4 it's a framework, so the measurement model
5 and the process model can contain whatever
6 you'd like to put in it. It can contain --
7 you know, the process model could contain
8 differential equation, and within that
9 differential equation, it could contain
10 sensor measurements. The measurement model
11 could -- could contain measurements. It
12 could also contain predictions. You can flip
13 however you want.

14 Q. So I understand it's a general
15 framework, but in the '438 patent, the
16 process model is a set of differential
17 equations based on time? That's Equation 1?

18 A. Yes.

19 Q. And the measurement model is based
20 on sensor data; is that correct?

21 A. It is -- yes, it is based on sensor
22 data. The -- to be clear, the process model
23 in this particular patent uses this
24 differential equation to describe what the
25 next state or the next orientation will be.

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2 But it does use measurement data as part of
3 it, which is the angular velocities.

4 Q. From the first --

5 A. From the measurement, from the
6 gyroscopes. Okay? And the measurement model
7 uses the measured acceleration, but it also
8 computes predicted acceleration, which stems
9 from the quaternion, which stems from the
10 angular velocity.

11 Q. Is there a specific -- so Equation 1
12 is the process model. Is there a specific
13 set of equations that is the measurement
14 model?

15 A. Typically, the measurement model is
16 often a vector that contains the measurements
17 and any other elements you want to put in it.
18 And then there is a function, the H-function,
19 which you see in Equation 8, that will
20 describe how the measurements -- it will
21 describe how the measurements that you have
22 sync up with the data that you get from the
23 process model.

24 Q. Let's just walk through these
25 equations, then. And starting with Equation

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2 5 --

3 A. Okay.

4 Q. -- what does Equation 5 do?

5 A. Equation 5 is really a
6 representation of the process model. The
7 function f is actually the process model, and
8 it's equal to x , which would be considered to
9 be a state vector or other quantity that
10 would give you the elements that you're
11 interested in; in this particular case, the
12 quaternion, for example.

13 So that's really what that equation
14 represents. It's a very general equation.
15 So there's a lot -- it's lots of different
16 things that you can do with it.

17 Q. So the inputs to f , which is the
18 process model, is x subscript $t-1$ and then a
19 variable called u subscript t . Let's start
20 with x_{t-1} . Which is that?

21 A. So x of $t-1$ would probably be the --
22 so these equations can be written in a number
23 of different ways. Okay? And the way that
24 they're writing equations in this particular
25 patent is to use a standard functional

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2 notation. Okay? Even though Equation 2 is
3 a matrix vector notation -- I'm sorry,
4 Equation 1 is a matrix vector notation.

5 So in the patent, Equations 5 and --
6 5 through 11 represent a blueprint, if you
7 will, for how this is done. And, as I said,
8 this can be done and written in many
9 different ways.

10 So the function f and the term x
11 minus -- x_{t-1} is generally referring to -- it
12 would be, for example, the quaternion at $t-1$,
13 and u of t would be, for example, the angular
14 velocity, let's say, in this case.

15 Q. What do you mean by "generally"? Do
16 you not know what x_{t-1} is?

17 A. No. I mean, it -- so what I'm
18 saying is that this equation, Equation 5, is
19 a general equation. Okay? And x of $t-1$ and
20 u of t min- -- and u of t could be a number
21 of different things in the scope of what a
22 Kalman filter does.

23 In this particular patent, x_{t-1}
24 would represent the quaternion -- the first
25 quaternion, and u of t would represent the

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2 angular velocity. But you'll notice that the
3 equations are not written in a form that is
4 amenable to the matrix vector notation.

5 They're just written in a general form. But
6 anybody who understands the Kalman filter or
7 extended Kalman filter would understand that.

8 Q. So I understand. You're saying it's
9 a general equation. You can put a number of
10 variables into it, but for the '438 patent,
11 it's putting in x_{t-1} , which is the
12 quaternion --

13 A. Yes.

14 Q. -- at $t-1$, and it's putting in u of
15 t --

16 A. The u velocity, which is the u of t .

17 Q. So that's how the '438 patent
18 specifically defines the process model?

19 MR. RAFILSON: Objection. Form.

20 A. Well, that's how the -- it is being
21 represented in the -- in the description. It
22 doesn't mean that there are other potential
23 ways that it could be done. And they say
24 that this is just one exemplary embodiment,
25 as you can see on Column 13, Number 25.

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2 BY MR. CHEN:

3 Q. Does it teach you how to use the
4 process model of any other variables?

5 MR. RAFILSON: Objection. Form.

6 A. In this particular instance, the
7 only -- the exemplary embodiment is the one
8 that I'm talking about, which is the
9 quaternions and the angular velocity in
10 Equation 5.

11 BY MR. CHEN:

12 Q. So does the '438 patent define a
13 process model with respect to any other
14 variables other than --

15 MR. RAFILSON: Objection. Form.

16 BY MR. CHEN:

17 Q. -- x?

18 A. It defines the process model,
19 Equation 1. That would be considered the
20 process model.

21 Q. So Equation 1 is the process model
22 to get the second quaternion?

23 A. Uh-huh.

24 Q. And then you use that in Equations
25 2, 3, and 4 --

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2 A. Uh-huh.

3 Q. -- to predict accelerations?

4 A. Yes.

5 Q. And then we're going to go to
6 Equation 5, and this is the same process
7 model or a different process model?

8 A. No, it would be the same process
9 model.

10 Q. So it's part of the same process
11 model?

12 A. Uh-huh. There is only one process
13 model in this particular embodiment.

14 Q. Are there any embodiments in the
15 '438 patent that use more than one process
16 model?

17 A. No.

18 Q. Are you aware of anywhere else in
19 the '438 patent that defines a process model
20 other than these equations?

21 MR. RAFILSON: Objection. Form.

22 A. Yeah. The patent itself does not
23 necessarily describe anywhere else a process
24 model. However, I would state that anyone
25 with ordinary skill in the art would

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2 understand that -- the process model that is
3 described in Equation 1 would be utilized in
4 Equation 5.

5 BY MR. CHEN:

6 Q. So you're saying -- and please
7 correct me again -- that these equations in
8 the '438 patent describe the '438 patent's
9 only disclosure of process model, but a
10 person of ordinary skill in the art would
11 know that there are other process models that
12 you can use?

13 MR. RAFILSON: Objection. Form.

14 Objection. Misstates testimony.

15 A. Anyone of ordinary skill in the art
16 would understand that these equations,
17 specifically Equations 5 through 11, are a
18 representative or a exemplary embodiment of
19 an extended Kalman filter and that there are
20 potentially other models that could be used.

21 BY MR. CHEN:

22 Q. Are these other models in the '438
23 patent?

24 A. No.

25 Q. So a person of ordinary skill in the

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2 art would know because there have been other
3 extended Kalman filters used?

4 A. Uh-huh.

5 Q. And that's well-known in the art?

6 MR. RAFILSON: Objection. Form.

7 A. Yeah. I mean, there's been a lot
8 of -- people have been using extended Kalman
9 filters for a while. So there's a lot of
10 work on it.

11 BY MR. CHEN:

12 Q. Do you know when extended Kalman
13 filters came around?

14 A. To the best of my knowledge, they
15 came around sometime in the '60s.

16 Q. Okay. So going back to Equation 5,
17 then the left side is $x(t \setminus t-1)$?

18 A. Yeah.

19 Q. What is -- is "t" time?

20 A. Yes. Well, it's time in integer
21 units. So a lot of times, we don't -- we
22 talk about time as being actual time, you
23 know, minutes and seconds, so on. But in
24 mathematics, we often describe time as simply
25 something that happened previously, something

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2 that happens currently, and something that
3 happens next. Right?

4 So this is basically saying the
5 state at time given the previous time, the
6 current time given the previous time. So, in
7 other words, it's saying the current state
8 given the previous state.

9 Q. So is that like one hour, it's more
10 state, prior state --

11 A. Yeah.

12 Q. -- next state?

13 A. Yeah. I mean, in terms of
14 implementing it, you would want to know what
15 the actual time was because it does make a
16 difference.

17 Q. So is t current state?

18 A. Yes.

19 Q. And then $t-1$ is prior state?

20 A. Uh-huh.

21 Q. And then you put that into a
22 function x . What is the function x ?

23 A. The function x , it's not a function,
24 actually. It represents the -- what is known
25 as the state vector.

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2 Q. Okay.

3 A. Or, in other words, a sequence of
4 data that we are getting from our process
5 model and any other data you wish to put into
6 it.

7 Q. So this -- so you solve for the
8 process model to get the state vector?

9 A. You solve the process model to get,
10 in general, the thing that you want to
11 estimate. But that does not mean that that
12 is the only thing that you may want to
13 estimate. And that thing that -- those are
14 -- the things that you may want to estimate
15 may not necessarily be part of the model.
16 They could be, but they don't have to be.

17 Q. So let's just take Equation 5. I'm
18 putting in the quaternion at the prior time,
19 $t-1$, and the angular velocity. What do I
20 get?

21 A. You would get the quaternion. The
22 second quaternion.

23 Q. So this -- we're specifically
24 talking about the f , the right side -- right
25 side of the equation?

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2 A. Oh, the right side of the equation
3 would be the first quaternion and the angular
4 velocity.

5 Q. That you're putting into the process
6 model?

7 A. Yes.

8 Q. So what is the output of that?

9 A. The output of that particular
10 function would be the quaternion, second
11 quaternion.

12 Q. The second quaternion?

13 A. Uh-huh.

14 Q. And that is a estimate of
15 orientation at time t?

16 A. Yes.

17 Q. Then how does that relate to the
18 state vector, because it says x is the state
19 vector --

20 A. Yeah.

21 Q. -- and then equals --

22 A. So we need a way to do the
23 mathematics. Right? And typically the way
24 that it's done is with this matrix vector
25 notation, so we put the results of the

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2 process model's estimate in a vector. We
3 call it the state vector because it's the
4 state of the system that we're trying to
5 estimate. Okay?

6 And in this particular case, we're
7 putting quaternion in here and potentially
8 other things, depending on how you would want
9 to implement it. In this particular case, it
10 would probably be just the quaternion.

11 Q. It would probably be or it has to
12 be?

13 A. Doesn't have to be.

14 MR. RAFILSON: Objection. Form.

15 A. Well, you have to have the
16 quaternion in there -- okay? -- because
17 that's what you're trying to estimate, but
18 you could put other things in there as well.

19 BY MR. CHEN:

20 Q. Does the '438 patent disclose
21 putting other things in there as well?

22 A. The particular embodiment does not.

23 Q. Does it disclose it at any other
24 embodiment?

25 A. The patent -- the embodiment that is

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2 discussed in the patent does not disclose
3 that you would put anything else in there
4 besides the quaternion. But given the fact
5 the patent also states that there are other
6 embodiments that could be incorporated, it is
7 feasible that someone could -- who implements
8 this and of ordinary skill in the art could
9 put something else in that state vector.

10 Q. But the '438 patent specifically
11 doesn't tell you to put anything else in
12 there?

13 A. That is correct.

14 Q. So this -- I put the second
15 quaternion into this state vector, and it
16 gives me an estimate of the state of the
17 system.

18 A. Yeah, or the thing that you want to
19 estimate. We call it a "system." You know,
20 it could be called a number of different
21 things.

22 Q. And, in this case, for the '438
23 patent, what I'm trying to estimate is the
24 orientation of the device.

25 A. Yes.

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2 Q. But isn't the second quaternion at
3 time t also an estimate of the orientation of
4 the device?

5 A. It is an estimate of the orientation
6 of the device, yes.

7 Q. So in putting it into the vector
8 model, do you just put it in a different
9 notation?

10 A. You would put it into a different
11 notation, yes.

12 Q. I guess my question is, why am I
13 putting it into the state vector if it's
14 already an estimate of the orientation?

15 A. Because you need to put it into a
16 vector-like, you know, representation because
17 we're going to use that later on to calculate
18 the covariance matrix for that estimate.

19 Q. So I need to do it to do the math
20 later?

21 A. Yes, do the math.

22 Q. So this process model f , there are
23 underlying calculations to this, right?

24 A. Yes.

25 Q. Are they disclosed anywhere in the

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2 '438 patent?

3 MR. RAFILSON: Objection. Form.

4 A. Yeah, they're disclosed in
5 Equation 1.

6 BY MR. CHEN:

7 Q. So f is really just Equation 1?

8 A. Basically, yeah.

9 Q. What do you mean, "basically, yeah"?

10 A. Well, what I mean is that it -- it
11 is -- f , in this particular case, is
12 Equation 1 outside of other potential things
13 that you could put into it.

14 What I'm trying to say here is that
15 equations -- these equations that we're
16 talking about, you know, 5 through 11, they
17 represent the blueprint, and anyone of
18 ordinary skill in the art would recognize the
19 blueprint and also recognize that there is
20 some liberty in what you can do with it.

21 Okay?

22 So the '438 patent does disclose
23 that Equation 1 is essentially the process
24 model and would be equivalent to F . And the
25 result of that would be then put into a state

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2 vector. But it does not necessarily mean
3 that there could be other things that you
4 could do. Right? Because this is just a --
5 one embodiment of the present invention.

6 Q. No, I understand like the general
7 framework concept. I understand. But the
8 '438 patent doesn't specifically -- like,
9 this is the only specific set of equations
10 that it uses that are disclosed; is that
11 correct?

12 A. These are the only specific set of
13 equations that describe an extended Kalman
14 filter framework.

15 Q. So in this specific description of
16 the framework, the f in Equation 5 is
17 Equation 1?

18 A. Yes.

19 Q. And the whole point of this is just
20 to put it into the state vector so I can do
21 some calculations later. That's the point of
22 Equation 5?

23 A. Pretty much, yeah.

24 Q. If you go one equation down -- and I
25 don't think it's numbered.

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2 A. Yeah.

3 Q. Let's start with the left side.

4 MR. RAFILSON: Counsel, down from
5 what, just to be precise?

6 MR. CHEN: Down from Equation 5,
7 right above Equation 6.

8 MR. RAFILSON: Ah.

9 BY MR. CHEN:

10 Q. It starts -- the left side starts
11 $P(x_t | x_{t-1}, u_t)$. So I'm assuming the
12 $(x_t | x_{t-1}, u_t)$, those mean the same things.
13 So x --

14 A. Say again, please.

15 Q. Those mean the same thing, so x_t
16 would be the second quaternion?

17 A. Yes.

18 Q. And then x_{t-1} is the quaternion at
19 time $t-1$?

20 A. Uh-huh.

21 Q. And then u_t is angular velocity?

22 A. Yes.

23 Q. What is P ?

24 A. P is a covariance matrix.

25 Q. What is a covariance matrix?

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2 A. A covariance matrix is a matrix that
3 describes variance and variance between
4 variables. So diagonal of the matrix is a
5 variant -- it's actually the variance -- the
6 term variance -- right? -- as average mean
7 and variance is the variance with respect to
8 elements in the state vector, and the
9 off-diagonal elements represent the
10 variability between individual elements of
11 the state vector.

12 Q. So what do I get when I plug in
13 these variables into this covariance matrix?

14 A. Well, you're not plugging these
15 variables into the covariance matrix. You're
16 calculating the covariance matrix.

17 Q. Using the variables?

18 A. Yes. I mean, you're taking the
19 right-hand side, and you're doing that
20 calculation to compute the left-hand side.
21 So those things on the right, those terms on
22 the right are going to be computed to give
23 you the covariance matrix.

24 Q. So the left is the output of the
25 right?

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2 A. Yes.

3 Q. So then let's go to the right side,
4 then. It starts with F_x . What's F_x ?

5 A. F of x represents the Jacobian
6 matrix of the process model.

7 Q. What does that mean?

8 A. So as I said in the extended Kalman
9 filter, you need to linearize the models so
10 that you can work with them. And the
11 Jacobian matrix is nothing more than the
12 derivatives -- the partial derivatives of
13 every term in the matrix. And that
14 effectively will compute a linearization of
15 that process model.

16 Now, you see it's capital F ? And we
17 have lowercase f , right? So what's done is
18 that the process model is put into a form, a
19 matrix form, that can be linearized. Okay?
20 And what it's doing is effectively computing
21 those -- that Jacobian matrix -- that's what
22 F_x and F_u are. So it's computing the
23 Jacobians matrices of the angular velocity
24 data.

25 THE REPORTER: I'm sorry. It's --

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. It's computing the Jacobians of the
3 angular velocity information and the
4 quaternion information.

5 BY MR. CHEN:

6 Q. So that's Equation 6?

7 A. 6 and 7, yeah. You need to do 6 and
8 7 in order to get -- to do equation of it.

9 Q. So Equation 6 is getting the
10 Jacobian matrix of the process model?

11 A. That's right. Well, both of them
12 are, 6 and 7, because we've got two
13 variables, so doing partial derivatives. And
14 to do partial derivatives, you have to
15 calculate -- basically, you calculate
16 derivative and then keep the other variable
17 constant, and then you do the same thing with
18 the other one.

19 Q. So 6, the variable that I'm keeping
20 constant is x_{t-1} , the lower of the division?

21 A. No. Actually, you're keeping u_t
22 constant in 6, and you're keeping -- wait a
23 minute. Yes, 6 you're keeping u_t constant,
24 and you -- you're keeping x of $t-1$ constant.

25 Q. In 7?

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2 A. Yes.

3 Q. So now going back up, it goes F_x ,
4 which is the Jacobian matrix -- am I
5 multiplying that by --

6 A. Yes. You're multiplying
7 $F_x P(x_{t-1} | x_{t-1})$.

8 Q. And then multiplying that by $F_x T$?

9 A. Transpose.

10 Q. Transpose?

11 A. Yeah.

12 Q. I'm adding that to F of u , which is
13 the Jacobian matrix, and then $P(u_{t-1} | u_{t-1})$?

14 A. Yes.

15 Q. I'm multiplying that again by F_u
16 transpose?

17 A. Uh-huh.

18 Q. I'm adding something called Q_t ,
19 which is additional motion noise?

20 A. Uh-huh.

21 Q. What do you understand additional
22 motion noise to be?

23 A. It's a extra term that's applied to
24 account for potential errors and noise in
25 your process model.

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2 Q. What kind of errors and noise?

3 MR. RAFILSON: Objection. Form.

4 A. So the model that you have, the
5 process model, is not -- it is a model.
6 Therefore, it is not perfect. So it may, you
7 know -- it may do well in estimating the --
8 in this case, the quaternion, and it may not
9 do well, depending on various things --
10 right? -- the world. So that noise is --
11 that term is added in there to account for
12 that noise and that -- the potential errors
13 that could occur.

14 BY MR. CHEN:

15 Q. So what specifically are you talking
16 about? Like what kinds of noise?

17 MR. RAFILSON: Objection. Form.

18 A. Okay. So -- how deep do I want to
19 get into this?

20 So the -- the process model --
21 right? -- is a way to describe behavior in
22 the world. Okay? However, in general -- all
23 right? -- the world or states of things in
24 the world are, unfortunately, unobservable --
25 okay? -- if you think about it. So -- and

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2 there are unobservable because we can
3 measure, we can predict, but to get an actual
4 representation is difficult -- okay? -- just
5 because of the nature of the universe.

6 So given that, we know that there's
7 going to be some variability. Okay? And we
8 add that term -- all right? -- to account for
9 that variability. This Q is actually a
10 random variable based on a distribution. And
11 the distribution can be, you know, whatever
12 you want it to be. So that term is added to
13 this covariance matrix to give a cushion, if
14 you will, to the filter to support it in
15 its -- in its ability to compute the
16 prediction of the estimate. Okay? This is
17 standard stuff.

18 BY MR. CHEN:

19 Q. So this is just sort of, "I know the
20 world is imperfect, so I'm going to add this
21 variable to account for the fact that the
22 world is imperfect"?

23 A. Pretty much. It's more specifically
24 to account for the world that my model is
25 imperfect -- right? -- process model. It's a

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2 process noise matrix. When we get to the,
3 whatever it is, Equation 9, we have another
4 one of these types of things for the
5 measurements because the measurements are
6 imperfect too.

7 Q. So this wouldn't account for
8 measurement inaccuracies with respect to the
9 sensors? This is a different thing?

10 A. Yeah. This is noise and
11 inaccuracies with the model that you're using
12 to describe the behavior that you're trying
13 to describe, the phenomenon you're trying to
14 model.

15 Q. So can you give me an example of
16 that in terms of -- because we're trying to
17 estimate orientation. What --

18 MR. RAFILSON: Objection. Form.

19 A. So given the very nature of the
20 orientation movement, there may be some
21 errors associated as you continue the process
22 of predicting and correcting and so on and so
23 forth. Right? It's not exact. Right? This
24 is a probabilistic or statistical model, the
25 Kalman filter. It's stochastic, or however

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2 you want to call it. It utilizes the
3 concepts of probability, mean, variance, to
4 do the calculations, and, as such, there is
5 an inherent variation or variability with the
6 whole process. Right?

7 So, you know, a lot of times, you
8 don't know what underlying error is or the
9 noise could be. So when Kalman invented this
10 thing, he put that in there to take into
11 account these unknowns that we have. Okay?
12 That's really what it's doing. If I knew
13 what it was, if I knew the exact sources of
14 the process error, I could model them. But I
15 don't.

16 BY MR. CHEN:

17 Q. So this is just -- there is some --
18 there has to be some unknown variable because
19 that's just how models work?

20 A. Uh-huh.

21 Q. They're imperfect?

22 A. Yeah.

23 Q. So in order to make this more
24 realistic, I'm going to add in this variable
25 that accounts for the fact that it's an

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 imperfect model?

3 A. Yes.

4 Q. And that's different than how the
5 Kalman filter -- this variable, I should say,
6 Q_t , is different from how the Kalman filter
7 deals with noise and errors in the sensors
8 themselves. That's later on?

9 A. Yeah. That's separate.

10 Q. So once I calculate 6 and 7 and I do
11 the full right-hand side of the equation
12 right above Equation 6 and 7, I get a
13 covariance matrix?

14 A. Yes.

15 Q. That describes the variability
16 between what?

17 A. Variability of the estimates of the
18 individual components in the state vector and
19 the estimates -- and the individual or the
20 correlations between -- or the variability
21 between each individual estimate because
22 there could be variation that goes, you know,
23 between two variables. That's why it's
24 called "covariance matrix."

25 Q. So in this case, what individual

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2 components am I sort of correlating between?

3 A. The individual quaternion
4 components. So the diagonal would give you
5 the variance for q_0 , q_1 , q_2 , q_3 , and then the
6 off-diagonals would give you, for example,
7 the variation for the variance between q_0 and
8 q_1 , q_0 and q_2 , and so on.

9 Q. So is it the variation between the
10 first and second quaternions --

11 A. No.

12 Q. -- or it's just a variation in a
13 single quaternion?

14 A. Single quaternion.

15 Q. And the single quaternion is the
16 second quaternion?

17 A. Yes.

18 Q. What other variances am I getting
19 from this matrix?

20 A. In this particular case, it would be
21 anything else that would be associated with
22 the state vector. So for whatever is in the
23 state vector, you're going to have an
24 equivalent that the state vector is, you
25 know, eight elements -- has eight elements in

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2 it. Your covariance matrix would be an
3 eight-by-eight matrix because it would need
4 to account for all the variables in that
5 state vector.

6 Q. In this case, my state vector is
7 only the quaternions?

8 A. Uh-huh.

9 Q. So in the '438 patent's disclosure?

10 A. In the disclosure, yes.

11 Q. And all these equations -- 6, 7, and
12 the equations you get to get the covariance
13 matrix -- these are all well-known in the
14 art -- or were well-known -- sorry -- were
15 well-known in the art at the time of the
16 invention of the '438 patent; is that
17 correct?

18 MR. RAFILSON: Objection. Form.

19 A. Yeah, they're standard Kalman --
20 extended Kalman filter equations.

21 BY MR. CHEN:

22 Q. Okay. Can we move to Equation 8.

23 A. Yeah.

24 Q. And I'm assuming, just like the
25 other ones, I'm solving for the left side?

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2 A. Yes.

3 Q. So what am I solving?

4 A. Well, in this case, what you're
5 doing is -- all right. This one's a little
6 bit different. Okay? This equation is
7 basically trying to show that there is a
8 equivalence between the measurement model,
9 which is z , and the state vector, x , and it's
10 doing that through the function h .

11 So the measurement model, I mean, we
12 already -- we have that information. It's
13 whatever we're measuring. Okay? In this
14 case, we have, you know, the predicted
15 acceleration. We have the measured
16 acceleration. And we'd also have the -- a
17 quaternion in there as well.

18 Q. So this isn't really solving for
19 something. This is just showing there's a
20 relationship between those two?

21 A. Yeah, uh-huh.

22 Q. And then for my measurement model,
23 why is it $t \backslash t-1$?

24 A. It's consistency of notation. It's
25 basically just saying, you know, get the

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2 measurement from the previous, you know, to
3 the current.

4 Q. So these are all the measurements
5 I'm getting from the sensors --

6 A. Uh-huh.

7 Q. -- from some previous point in time
8 and a current point in time?

9 MR. RAFILSON: Objection. Form.

10 A. So in this particular case --
11 right? -- this -- this embodiment is slightly
12 different in that the measurement model
13 contains the measured acceleration and also
14 contains the predicted acceleration. Okay?
15 So you have something that is represented
16 as -- you know, that was already calculated
17 and then something that was calculated based
18 on measurements from prior state -- or prior
19 time.

20 BY MR. CHEN:

21 Q. And that's all that's in z?

22 A. So z would probably also have to
23 have a quaternion in it.

24 Q. What do you mean, "probably also"?
25 What does it have in it?

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2 A. Well, based on the patent, in order
3 to get to the appropriate equations, you
4 would have to have a quaternion in the
5 measurement model to compare with the
6 measurement, the process model, because it
7 has a quaternion in it as well. But we don't
8 have anywhere to measure the quaternion,
9 per se. Okay? What we have is the measured
10 acceleration and the predicted acceleration.

11 So what this thing would do is
12 compute a quaternion based on the measurement
13 data and the predicted -- well, it would
14 compute it based on the measurement data.

15 Q. So what you're saying is the
16 measurement model takes the measured
17 accelerations and the predicted accelerations
18 and then computes a quaternion?

19 A. Yes. That's what it would do.

20 Q. And that quaternion is an estimate?

21 A. It's an estimate based on the
22 measurements.

23 Q. An estimate of orientation?

24 A. Yes.

25 Q. Based on measured accelerations and

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 predicted accelerations?

3 A. Uh-huh.

4 Q. Does the '438 patent disclose how to
5 do this, or does a person of ordinary skill
6 in the art just know how to do this?

7 MR. RAFILSON: Objection. Form.

8 A. A person of ordinary skill in the
9 art would -- well, the patent does disclose
10 that the predicted accelerations and the
11 measured accelerations would be in the
12 measurement component. A person of ordinary
13 skill in the art would then have to -- would
14 know that they would need to compute the
15 quaternion in order to make this work.

16 BY MR. CHEN:

17 Q. But it doesn't say it anywhere. You
18 just know because that's how the process is
19 supposed to work?

20 A. Uh-huh. That's correct.

21 Q. Okay. Move to the right side of the
22 equation. So x , again, is the state vector?

23 A. Yes.

24 Q. And then so what is h ?

25 A. h is a function that basically

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2 describes or transforms the state vector into
3 a form so that it can be compared with the
4 measurement information.

5 Q. So my state vector at this point is
6 a second quaternion at time t ?

7 A. Uh-huh.

8 Q. And I'm comparing it with a
9 quaternion that is calculated using measured
10 and predicted accelerations; is that right?

11 A. Yes.

12 Q. And that's Equation 8, in a
13 nutshell?

14 A. Yeah. It's -- h , basically, is the
15 thing that's going to tell us how to -- it's
16 going to do the necessary work to ensure that
17 we can compare the measurement model -- the
18 measurement data with the process data, the z
19 and x .

20 Q. How does it do that?

21 A. The function h ?

22 Q. Yeah.

23 A. It would -- in this particular case,
24 there's lots of different ways to do it. The
25 patent doesn't explicitly disclose how it

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2 does it, but in this particular case, it
3 would probably simply just ensure that the
4 length of the vector -- state vector and the
5 length of the measurement vector would be
6 equivalent so that they could be compared
7 properly.

8 Q. So are all these equations -- were
9 they well-known in the art at the time of
10 invention of the '438 patent?

11 MR. RAFILSON: Objection. Form.

12 Objection. Asked and answered.

13 A. Yeah, they are.

14 BY MR. CHEN:

15 Q. Let's go down to Equation 9. And,
16 again, I'm assuming I'm solving for the left
17 side?

18 A. Yes.

19 Q. But I have to do Equation 10 first?

20 A. Yes, that's right.

21 Q. So what's Equation 10?

22 A. Equation 10 is analogous to the
23 Equations 6 and 7. They represent the
24 Jacobian of the matrix -- or it's the
25 Jacobian of the H-function, which is the

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2 function that is going to make sure that you
3 are converting the process state and the
4 measurement state such that they can be
5 compared.

6 Q. And then you put that into Equation
7 9?

8 A. That's right.

9 Q. So what is the right-hand side of
10 Equation 9?

11 A. Equation 9, the right-hand side is
12 the calculation to compute the covariance
13 matrix for the measurement model or the
14 measurement information. So it takes the
15 Jacobian, multiplies it by the covariance
16 matrix, multiplies that by the transpose of
17 the Jacobian, and then adds the measurement
18 noise.

19 Q. So left side is a represen- -- is
20 like a -- is the Jacobian matrix of the
21 measurement model, is what I'm getting?

22 A. You're referring to Equation 10?

23 Q. I'm sorry. Equation 9, the left
24 side of the equation.

25 A. The left side represents the

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2 variability that would be associated with the
3 measurement model.

4 Q. So what is R_t ?

5 A. R_t is considered to be measurement
6 noise or a matrix that would introduce noise
7 into -- or basically to account for noise in
8 error associated with any measurements you
9 would have.

10 Q. So R_t is a matrix?

11 A. Yes.

12 Q. And what is measurement noise?

13 A. Sensors are not perfect. They --
14 there's a variety of different things that
15 you can get. I'll give you an example. I
16 can take a measurement device and put it and
17 make it stationary, and I can look at the --
18 you can see jitter in the data. That jitter
19 would be considered noise.

20 We need to model that as part of our
21 process or as part of the measurement model,
22 so we would use that matrix to introduce and
23 say, "Here's this noise that's associated
24 that we want to account with our
25 measurement."

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2 Q. Is that like electronic noise?

3 A. Yeah, could be electronic noise,
4 inaccuracies in the actual sensors, humidity,
5 all kinds of things.

6 Q. So it's like I'm getting a
7 measurement, but it's not really completely
8 accurate because maybe there's some
9 electronic thing or --

10 A. Once again, you're using a -- the
11 sensor is a way to measure something that's
12 not directly observable. Right? At most, we
13 can do our best guess at getting that
14 quantity, and we know that there's going to
15 be errors and potentially noise associated
16 with that measurement. So this accounts for
17 that.

18 Once again, it's a random variable.
19 It acts as a -- you know, a cushion, if you
20 will, to help the filter do its job.

21 Q. What do you mean by "random
22 variable"? Like, what is the -- how do I
23 know what matrix to put into this? Is it --

24 A. Well, I mean, first of all, you're
25 not putting -- you mean how do I know -- how

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 do you know what --

3 Q. How do I know what the Rt matrix --

4 A. What to put into Rt?

5 Q. Yeah.

6 A. It depends on -- it's one of these
7 things that is kind of like initializing
8 something. Right? There's many different
9 things that you can do to initialize, you
10 know, a variable. Or, like, let's say I have
11 a parameter that I have in an algorithm.
12 That parameter could be anything. Right?
13 It's based off and on intuition. Best guess,
14 sometimes actually taking the -- in this
15 case, the measurement of the devices
16 themselves and actually looking at how they
17 measure. Sometimes you can get it from
18 specifications from the manufacturers who
19 will tell you, you know, this is going to
20 measure, you know, angular velocity plus or
21 minus .01 degree. Okay?

22 Q. Yeah.

23 A. Or whatever.

24 Q. Right.

25 A. Whatever in the way of the current.

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2 You can use that. Right? It's subject to
3 the person implementing its interpretation
4 and how they best -- and how they want to use
5 it.

6 Q. And just to go back briefly to the
7 equation above 6 and 7, Q_t , motion noise?

8 A. Yes.

9 Q. That's the same sort of intuition?

10 A. Yes.

11 Q. Different variables?

12 A. Yes. There are -- some people will
13 estimate it based on, you know, the model
14 that they're using. Very often, they'll
15 introduce noise as part of the derivative --
16 as part of, like, the highest derivative that
17 is being used in the model because that's the
18 most noisy. There are ways to actually
19 calculate the process matrix analytically.
20 It depends. There's lots of different ways
21 to do it.

22 Q. Are there any types of noise that
23 you couldn't account for so that you wouldn't
24 put it into this Kalman filter?

25 A. No. The beautiful thing about the

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2 Kalman filter is that it's -- by utilizing --
3 there are lots of places where, you know,
4 you're accounting for noise. You can account
5 for noise with -- you account for noise with
6 R_t and Q_t , but you can also account for noise
7 in process models, for example. You can add,
8 you know, noise terms to them if you want.

9 So, pretty much, it's designed to
10 account for, you know, the noise that's in
11 the process or -- model or in the
12 measurements and done in such a way that you
13 wouldn't necessarily discount any -- any
14 noise that would be available -- that would
15 be out there.

16 Q. But for these equations, the process
17 model doesn't have a noise variable?

18 A. Yeah. Equation 1 does not have
19 that.

20 Q. So in these set of equations, how
21 you would deal with measurement noise is
22 really --

23 A. Well, I mean, in these set of
24 equations, you would deal with -- the thing
25 with Equation 1 you could deal with it

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2 through Q_t , the process.

3 Q. The motion noise too?

4 A. Yes, the motion noise, as they call
5 it.

6 Q. So in these set of equations, how
7 you would deal with noise is through the
8 matrices' Q_t and --

9 A. Yes, primarily. You could increase
10 or decrease them, depending on, you know --

11 Q. What do you mean, "primarily"? Is
12 there any other --

13 A. Well, I mean, like I said, there
14 are -- you can introduce noise in different
15 parts of the filter or in different -- in the
16 models. Okay? But if you don't, you can
17 utilize Q_t and -- for example, to account for
18 that noise.

19 Q. But in these set of equations, the
20 only noise variables are Q_t and R_t ?

21 A. In these set of equations, that is
22 correct. However, anyone of ordinary skill
23 in the art would understand that you could
24 add other noise terms as part of this whole
25 calculation.

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2 Q. Right, that you could add them. But
3 in these equations, the only two noise
4 variables are Q_t and R_t ?

5 A. In these specific equations, yes,
6 that is correct.

7 MR. CHEN: Can we go for about 20
8 more minutes and then lunch?

9 MR. RAFILSON: That should be fine.
10 I'm going to have to check out at some
11 point. So, yeah. Why don't we do this:
12 why don't we take a five-minute break
13 real quick.

14 MR. CHEN: You want to get your
15 bags?

16 MR. RAFILSON: Yeah. Let me just
17 get my bag, and then we'll go another --

18 MR. CHEN: 20 minutes.

19 MR. RAFILSON: Yeah. That's fine.

20 MR. CHEN: Sounds good.

21 (Break taken from 11:21 a.m. to
22 11:34 a.m.)

23 BY MR. CHEN:

24 Q. So going back to Equations 9 and 10,
25 all these were well-known in the art at the

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2 time of invention of the '438 patent; is that
3 right?

4 A. Yeah.

5 MR. RAFILSON: Objection. Form.

6 BY MR. CHEN:

7 Q. So R_t is measurement noise, and Q_t
8 is additional motion noise. What is the
9 difference between R_t and Q_t ?

10 A. Q_t is -- is noise associated with
11 the process model, and R_t is noise associated
12 with the measurement model.

13 Q. So R_t would be noise associated with
14 the sensors themselves?

15 A. Yes, that's right. Whereas, Q_t is
16 noise associated with the model that's being
17 used, the predictor part of the filter.

18 Q. Okay. So let's look at Equation 11,
19 which is the last equation to this extended
20 Kalman filter; is that correct? And then the
21 left side is what I'm solving for?

22 A. Yes.

23 Q. And what is that? What's DT ?

24 A. Dt is a matrix.

25 Q. Matrix representing what?

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2 A. That's a matrix that would be
3 holding -- actually, the -- that would
4 probably be the error that's associated with
5 the comparison between the measurement noise
6 and the process noise -- I'm sorry -- the
7 measurement and the process data.

8 Q. Probably be or is?

9 A. To the best of my knowledge, I would
10 say it is.

11 Q. To your knowledge, is there anything
12 else it could be?

13 A. It's also -- potentially could be
14 utilized as a -- the matrix could be utilized
15 to capture the actual quaternion itself, the
16 third quaternion, which would then be used
17 as, you know, the estimate of the orientation
18 of the device.

19 Q. So it's either an error message or
20 the third quaternion?

21 A. No, not an error message.

22 Q. Sorry. Either error --

23 A. It either represents the error
24 associated with the comparison between the
25 two, which could then be used to determine

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2 which quaternion you wanted to use, or it
3 could contain the quaternion itself. You can
4 see on the right side of the equation that
5 it's actually doing a comparison between the
6 measurement and the process and then
7 multiplying that by the covariance.

8 Q. So the z_t is the measurement?

9 A. Uh-huh.

10 Q. And multiplying it by P ?

11 A. Yes.

12 Q. $x_t|z_t$, that's the covariance?

13 A. Yes.

14 Q. And then again, $x(t|t-1)$, that's the
15 state vector?

16 A. Uh-huh.

17 Q. h is what allows me to do this
18 calculation?

19 A. Yes.

20 Q. So I'm comparing z , which is the
21 measurement model, with the state vector?

22 A. Yeah, or the resulting from the
23 process model. Everything's been building up
24 to this point so that we can do this
25 comparison.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. So it's basically a comparison
3 between the measurement model and the process
4 model?

5 A. Uh-huh.

6 Q. Which either gives me sort of the
7 difference so I know which one to pick?

8 A. Yeah. I mean, as you can see, in
9 the paragraph above Equation 11, that this is
10 an illustrative example. Okay? So as an
11 illustrative example, it's subject to some
12 interpretation.

13 So, yes, it's possible that you
14 could utilize this in a number of different
15 ways. One of the ways would be as an error
16 term to determine which -- which piece you
17 trust more and want to use, the measurement
18 or the prediction, or to potentially use as a
19 way to calculate the third quaternion itself.

20 Q. Let's take the case when it's the
21 error. I think you stated earlier that you
22 have to weight or assign a weight to both
23 models. Is that what it's doing in
24 Equation 11?

25 A. Yeah. The covariance is part --

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2 partially is the main thing that's being used
3 to do that.

4 Q. So the $P(z_t|x_t)$ is assigning a
5 weight to -- sorry. Doing that
6 calculation --

7 A. Yeah.

8 Q. -- will assign a weight to the --

9 A. Right. Because, I mean, if you look
10 at it, what's actually happening is you're
11 taking that and you're multiplying it by both
12 z and t and x . You're multiplying them -- if
13 you distribute it out. So you see that acts
14 as a weight to the measurement and to the
15 process model, which includes the state
16 vector that we talked about.

17 Q. So that $P(z_t|x_t)$ -- $P(x_t|x)$ gives me
18 a weight?

19 A. Yeah. I mean, it's the covariance,
20 but we can use it as a weight.

21 Q. Why am I multiplying that by all
22 these other state vectors?

23 A. That is -- we have to do that in
24 order to get the math to work out.

25 Q. But the main part of it is the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 covariance, because that's the weight?

3 A. Well, I mean, actually, really, the
4 main part of it is the subtraction, the
5 subtraction of the measurement and the
6 process -- the measurement data and the
7 process data -- right? -- because that's
8 going to give us a difference, comparison, if
9 you will. And then multiplying each one of
10 those by that weight will help give us an
11 indication about which one is more accurate
12 in the optimal sense.

13 Q. Okay. So left side, $z_t - h(z_t | t-1)$,
14 that's the -- that's one of the subtractions
15 you're talking about?

16 A. So, yeah. I mean, there's that one,
17 and you have to do it twice. It's analogous
18 to -- if you look at Equation 9, you see
19 there's an Hx , and then there's a
20 $P(x_t | x_{t-1})$ and then Hx transpose. It's
21 similar, and in order to get the math to work
22 out, you have to multiply on either side of
23 the covariance matrix.

24 Q. Z_t here is still the measurement
25 model?

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2 A. Yeah. I noticed that.

3 Q. And then x is the state vector
4 model?

5 A. Yes, that is correct. x is the
6 measurement and -- I'm sorry. z is a
7 measurement. x is the process --
8 quote/unquote, process model/process data
9 from the state vector.

10 Q. So on one side -- I guess I don't
11 really understand the subtraction. What's
12 the difference between these two
13 subtractions?

14 A. Yeah. It's a very good question.
15 That very well might be a typo. The first
16 one, $z_t - h(z(t|t-1))$, that z term I believe
17 should be x .

18 Q. So that would -- that makes sense
19 from your testimony because you were saying
20 you have to do it twice?

21 A. Uh-huh.

22 Q. And then multiply it by the
23 probability covariance?

24 A. Yes.

25 Q. And that gives you error or third

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 quaternion?

3 A. Uh-huh. The error could then be
4 taken to -- use it to derive the third
5 quaternion. I'll just reiterate that this
6 is -- this Equation 11 is illustrative only.
7 I mean, you can use it, but there are a
8 number of other ways to do this that will get
9 you the -- the error and also the third
10 quaternion.

11 Q. Does the '438 patent disclose
12 another way to get the error?

13 A. It does not, but it states that this
14 is an illustrative example.

15 Q. Does the '438 patent disclose
16 another way to get the third quaternion?

17 MR. RAFILSON: Objection. Form.

18 A. It specifically does not.

19 BY MR. CHEN:

20 Q. So Equation 11 is the only
21 calculation that the '438 patent discloses?

22 A. Discloses, yes.

23 Q. To get the third quaternion or
24 error?

25 A. Uh-huh.

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MR. RAFILSON: Objection. Form.

BY MR. CHEN:

Q. And this calculation, to get the error and the third quaternion, that was well-known in the art at the time of the invention of the '438 patent, right?

MR. RAFILSON: Objection. Form.

Objection. Asked and answered.

A. Yeah. This particular equation is -- it's common, but I wouldn't say well-known.

BY MR. CHEN:

Q. It is just known?

A. It's known.

Q. Because it's all part of that extended Kalman filter, which is well-known?

MR. RAFILSON: Objection. Form.

A. Yes.

MR. CHEN: Okay. Why don't we break for lunch.

MR. RAFILSON: Sure.

(Luncheon recess from
11:49 a.m. to 1:01 p.m.)

///

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. CHEN:

3 Q. So welcome back from lunch. Before
4 lunch, we were just talking about, you know,
5 the enhanced comparison method and the
6 extended Kalman filter and the '438 patent.
7 And you testified that extended Kalman
8 filters can also deal with sensor fusion; is
9 that correct?

10 A. Yes.

11 Q. So is that in the measurement model?

12 A. No. Well, it can be. The extent
13 the Kalman filter in terms of sensor fusion,
14 you can think of it more holistically. So
15 the sensors can be -- you can use that -- the
16 measurement model to help fuse sensors, but
17 you can also use the process model as a way
18 to assist in that fusion as well. Okay. So
19 it's flexible.

20 Q. So let's start with the first -- the
21 process model. How do I use the process
22 model to help me combine the results of the
23 sensors at issue here, which are the
24 gyroscope, the accelerometer -- and the
25 accelerometer?

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2 A. Well, if you look at the figure or
3 at Equation 1, going back to the '438 patent,
4 you'll see that the process model takes the
5 angular velocity as its -- as one of its
6 inputs.

7 Okay. So that's one sensor --
8 excuse me -- sensor data. And then you've
9 got the predicted axial accelerations and the
10 axial accelerations that are computed from
11 the accelerometer and the predicted axial
12 acceleration, which is predicted from the
13 quaternion, which is computed from the
14 angular velocity. That, in and of itself, is
15 a type of sensor fusion because you're taking
16 these sensors and you're putting together in
17 a certain way to get other types of
18 information. Right? So, you know -- so
19 that's what -- you know, that's one example
20 of fusing the data together to get a better
21 estimate.

22 Q. But in Equations 2 through 4, that
23 first quaternion is based on the angular
24 velocities?

25 A. Yes.

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2 Q. And I'm just calculating predicted
3 accelerations based on those angular
4 velocities?

5 A. Yes.

6 Q. So your definition, I guess, of
7 sensor fusion is being able to use the
8 reading of one sensor to get a value?

9 MR. RAFILSON: Objection. Form.

10 A. No. My definition of sensor fusion
11 is to -- first of all, there are many
12 definitions of what sensor fusion is because
13 there's a lot of different ways that you
14 would consider fusing sensors together.

15 BY MR. CHEN:

16 Q. So let's take the '438 patent's
17 disclosures.

18 A. Right. So in this case, what it's
19 doing is it's combining -- you know, it's
20 fusing together these measurements in such a
21 way that it's calculating and deriving
22 measurements or quantities from the
23 measurement data in order to do appropriate
24 comparisons. So it's not comparing
25 directly -- right? -- and it's not fusing

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2 directly, but it's fusing indirectly because
3 it's utilizing sensors to compute quantities
4 that can be then compared. Right?

5 I mean, in this patent, one of the
6 first things you see is there's no
7 measurement for the quaternion, right? What
8 we're doing is deriving the quaternion, and
9 we're using the various measurements to do
10 it. We're using the predicted axial
11 accelerations, and we're using the angular
12 velocities. Right?

13 But in both cases, what we can do is
14 then compute a quaternion from those and then
15 compare them. So that is effectively taking
16 those sensors and fusing them together.
17 We're just fusing them together in a way that
18 requires a transformation for each one.

19 Q. So the '438 patent discloses
20 calculating a set of predicted accelerations
21 from the first quaternion and adding --

22 A. It's not from the first quaternion.
23 It's from the second quaternion.

24 Q. Oh, sorry. For the second
25 quaternion.

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2 And that is, in a sense, a type of
3 sensor fusion?

4 A. Yes.

5 Q. Because you're using the angular
6 velocities to create a first quaternion?

7 A. Second quaternion.

8 Q. Sorry.

9 A. Yeah.

10 Q. Second quaternion?

11 A. I know it's confusing. First,
12 second, third.

13 Q. How else does the '438 patent
14 accomplish sensor fusion?

15 MR. RAFILSON: Objection. Form.

16 A. Well, it also does it by -- you
17 know, Equation 11 is taking the quaternion
18 that is calculated from the process model,
19 and it's taking the quaternion that was
20 calculated using the predicted and measured
21 accelerations and combining them to get a
22 better estimate of the quaternion.

23 So in that sense, it's taking those
24 things and fusing them together in a way to
25 give you a better estimate of the quantity of

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2 interest.

3 BY MR. CHEN:

4 Q. So when you say there -- it's taking
5 these two quaternions and combining them,
6 like we were talking about before, that means
7 assigning a weight and then choosing which
8 one --

9 A. Well, you can assign a weight and
10 choose which one you prefer to use or you can
11 assign a weight and combine -- and actually
12 add them together, almost like a weighted
13 average.

14 Q. And what does Equation 11 do?

15 A. Equation 11 is -- Equation 11 is --
16 it's slightly unclear what Equation 11 is
17 doing. But based on the mathematics in it,
18 it is either going to combine the two
19 measurements -- it is combining the two
20 measurements together, the quaternion from
21 the measurement and the quaternion from the
22 process, combining them and outputting that
23 quaternion with the weights from the
24 covariance matrix, or it's going to be
25 computing a new error term that can be used

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2 to calculate the quaternion.

3 Either way, you are taking data from
4 different sensors and fusing them together.

5 Q. I understand the combination, but I
6 think you were saying that combination in
7 this context can mean assigning a weight and
8 choosing which one you believe more or sort
9 of just adding them together, right?

10 A. I mean, you can add; you can
11 subtract. You know, there's a variety of
12 different ways that you can fuse them
13 together.

14 Q. So what does Equation 11 actually
15 do?

16 A. Equation 11 is -- looks like it's
17 assigning weights to each of the
18 individual -- it's assigning weights to the
19 process and model -- the process information
20 and the measurement information, and then
21 using that, it's subtracting the two
22 together, and that is going to give you data
23 which then can be utilized to create that
24 third quaternion.

25 Q. So it's assigning a weight to the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 process model?

3 A. Uh-huh.

4 Q. And it's assigning a weight to the
5 measurement model?

6 A. Uh-huh.

7 Q. And it's subtracting which one from
8 what?

9 A. It's subtracting the process model
10 from the measurement model. I mean, at the
11 end of the day, you can do either one. I
12 mean, you can interchange it, just take the
13 absolute value of it or square it or whatever
14 it's going to give you.

15 Q. But the '438 --

16 A. In this one, it's taking -- it's
17 subtracting the process from the measurement,
18 which is typically the way that it is done.

19 Q. Is this subtracting the model or the
20 weight?

21 A. No. It's subtracting the actual --
22 not the model. It's subtract the data that
23 is derived from the models. So, effectively,
24 what it's doing is it is subtracting two
25 quaternions from each other and multiplying

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2 them by this covariance matrix, and that
3 covariance matrix is giving weights to each
4 one of those quaternions.

5 Q. So each model gives you a
6 quaternion, which is the measurement -- or an
7 estimate of orientation?

8 A. Yes.

9 Q. And then it subtracts the process
10 one from the measurement?

11 A. Uh-huh.

12 Q. So it subtracts the quaternion that
13 you get from the process model with the
14 quaternion you get from the measurement
15 model, and that gives you either error or the
16 third quaternion?

17 A. Yeah. That's correct.

18 Q. And, again, this equation is
19 well-known in the art --

20 MR. RAFILSON: Objection.

21 BY MR. CHEN:

22 Q. -- at the time of the '438 patent;
23 is that correct?

24 A. The equation is -- it's a common
25 equation. It's maybe not as well-known as

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 other forms of the Kalman filter equations.

3 Q. So it's just known?

4 A. It's known.

5 Q. So when you're combining the results
6 of different sensors, there's noise, right?

7 A. Yeah. There is going to be a little
8 bit of noise every step of the way.

9 Q. So is that what the Kalman filter is
10 doing? It's filtering out the noise to give
11 you the best estimate?

12 A. Yes and no. It does two things. It
13 does help to filter out noise, but it also
14 helps to determine what the best estimate is
15 based on -- you know, based on the best
16 estimate that you have at any point in time.
17 Okay? And that estimate that you're -- that
18 you have, the best estimate could be because
19 the other estimate doesn't have a lot of
20 noise associated with it, or it could be the
21 fact that it's just doing very well in
22 modeling the behavior at any particular point
23 in time. It changes and fluctuates as the
24 algorithm runs.

25 Q. So it's like I'm taking my best

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2 estimate using the angular velocities, which
3 is the process model, and I'm taking my best
4 estimate using the axial accelerations, which
5 is the measurement model, and I'm just trying
6 to figure out which one is the most accurate?

7 A. Most accurate, yeah, you could
8 characterize it as that.

9 Q. And that's one function of the
10 Kalman filter. And the other function is
11 there's some noise associated with these
12 sensors, and I'm going to filter those out?

13 A. Yeah, and they're related. It's not
14 like they're mutually exclusive.

15 Q. They're related because, like, the
16 sensors are where you get the angular
17 velocities to get the quaternions?

18 A. Right. Yeah.

19 Q. So what is different -- well, let me
20 ask you, are there any differences between
21 what is disclosed in the '438 patent and just
22 an extended Kalman filter?

23 A. So you're asking me are there any
24 differences between the extended Kalman
25 filter and what is disclosed in the '438

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2 patent?

3 MR. RAFILSON: Objection. Form.

4 A. Yes, there is a number of
5 differences because an extended Kalman filter
6 is simply a framework for doing -- or
7 estimating some phenomenon -- okay? --
8 whereas the '438 patent describes a 3D
9 pointing device that includes a housing and a
10 process printed circuit board and sensors and
11 a enhanced comparison method which ultimately
12 is -- can be considered a Kalman filter. So
13 it is much more than just an extended Kalman
14 filter.

15 BY MR. CHEN:

16 Q. Well, is there any difference
17 between the enhanced comparison method used
18 by the '438 patent and an extended Kalman
19 filter?

20 MR. RAFILSON: Objection. Form.

21 A. There are -- there are differences
22 with respect to how the filter is disclosed
23 and implemented, potentially implemented,
24 because we're not talking about
25 implementation here, but if you were talking

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2 about implementation.

3 So, you know, an extended Kalman
4 filter, like I said, is this general thing,
5 and by itself, you know, you can't really do
6 much with it until you actually begin to
7 populated it with pieces of appropriate
8 information that you need.

9 So they are different because one is
10 this general framework, whereas the other in
11 the '438 patent is a manifestation of
12 something that requires, you know, a number
13 of decisions to be made that the extent the
14 Kalman filter doesn't necessarily have on its
15 own.

16 BY MR. CHEN:

17 Q. But Equations 5 through 11 are the
18 general extended Kalman filter framework,
19 right?

20 A. They are.

21 Q. So what are these pieces that are
22 appropriate information that I need to fill
23 this --

24 A. You need to know what the process
25 model is, what the measurement model actually

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2 entails, how to calculate the Jacobians for
3 Equations 6 and 7 based on the form f . So
4 you need to know how to calculate f based on
5 your process model, which can be any number
6 of things, right?

7 Same thing with your measurement
8 model and your h matrix, which also can be on
9 any number of things, depending on what it is
10 that you are doing. Right? So in that
11 respect, those are the things -- you know,
12 the process noise, the measurement point,
13 this is a general framework, but, you know,
14 anyone of ordinary skill in the art would be
15 able to recognize it and understand that,
16 "Oh, okay. I see these equations. I
17 understand this is an extended Kalman filter,
18 and I also understand that there's things I
19 need to do in order to make it work," right?

20 The '438 patent teaches some of
21 that -- most of that in its equations and
22 handling. Some of it needs to be inferred by
23 basic understanding of extended Kalman
24 filter.

25 Q. So when you say the '438 teaches

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2 some of what you need to plug in, that's
3 taught in Equations 5 through 11?

4 A. I mean, it gives you, like -- for
5 example, it shows you you need this Q matrix,
6 and it shows you you need this R matrix,
7 right? But it's up to the person
8 implementing it to determine what the best
9 way to do that is. And anyone of ordinary
10 skill in the art would understand that.

11 Q. So it's the '438 patent gives you
12 sort of a open-ended framework; is that
13 correct?

14 A. Yes.

15 Q. And what you add into the framework
16 is what makes it different from a plain and
17 ordinary extended Kalman filter?

18 A. Yes.

19 MR. RAFILSON: Objection. Form.

20 A. It represents a manifestation of the
21 extended Kalman filter. Right? And what you
22 do with it in this makes it different.

23 Every Kalman filter -- extended
24 Kalman is potentially different depending on
25 how you set it up and what data you have,

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 what process models and so on and so forth.

3 BY MR. CHEN:

4 Q. So it's what you add into the
5 framework is what makes it different?

6 A. Yes.

7 Q. And the '438 patent gives you a
8 little bit about what you add into the
9 framework?

10 A. Gives you most of it.

11 Q. It gives you most of it in Equations
12 5 there through 11?

13 A. Uh-huh.

14 Q. And some of the --

15 A. Well, actually, Equations 1 through
16 11.

17 Q. Sorry. Equations 1 through 11?

18 A. Yeah. You have to have Equations 1
19 through 4 in order to be able to populate
20 Equations 5 through 11. If you don't have
21 that, then you don't know what your process
22 model would be. In some sense, the patent's
23 description of the process model and the
24 measurement that you're getting is more
25 important than Equations 5 through 11

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2 themselves, because if Equations 5 through 11
3 are in the standard ordinary skill in the
4 art, people understand. Right? But what the
5 patent is doing is, is describing, you know,
6 how you're actually setting it up with the
7 current framework and the current set of
8 measurements and stuff. That's where the
9 real difference lies in a standard extended
10 Kalman filter in its traditional form.

11 Q. So Equations 1 through 4 give you
12 the setup that you plug into Equations 5
13 through 11 that make it different from
14 extended Kalman filter -- oh, sorry -- from,
15 like, a plain, ordinary extended Kalman
16 filter?

17 A. Well, I mean, to say "plain,
18 ordinary extended Kalman filter," there's no
19 plain and ordinary extended Kalman filter. I
20 mean, Kalman filter -- extended Kalman filter
21 is going to be unique depending on -- every
22 one of them is going to be slightly
23 different, depending on what you want to do
24 with it.

25 Q. But all the underlying math of the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 extended Kalman filter is known, right?

3 MR. RAFILSON: Objection. Form.

4 Objection. Vague.

5 A. So the standard equations, yes, are
6 known, right? It's kind of like -- in
7 programming languages, very often there's --
8 there's a function in the C programming
9 language called qsort. Okay? And that
10 function runs a sorting routine. It's a
11 well-known sorting routine, right? But in
12 order to use it, you need a comparison
13 function to apply. And any comparison
14 function may be different, right?

15 So even though you're using the
16 basics of a sorting algorithm, the sorting
17 algorithm is really technically different
18 every time because you're using a different
19 comparison method as input to it and even
20 different data. So in that sense, it is
21 somewhat unique, depending on the parameters
22 that you provided.

23 In the same vein, we have a set of
24 parameters -- right? -- but not numbers.

25 Right? Some of them are numbers, but some of

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2 them are equations. Some of them are sensor
3 data -- right? -- that all sort of act as the
4 parameters that make any particular extended
5 Kalman filter unique.

6 BY MR. CHEN:

7 Q. Just looking at Equations 1 through
8 11, where are these parameters that uniquely
9 define the extended Kalman filter?

10 A. So the parameters that will uniquely
11 define the filter would be f , lowercase
12 function f . Okay? That function -- all
13 right? -- which we've already discussed is a
14 function that represents the quaternion
15 differential equation in Equation 1, but that
16 is a parameter. That function could be a
17 number of different things.

18 The Q matrix also is another
19 parameter that you can set to determine, you
20 know, what noise you want to include as part
21 of the process. The z function, which
22 represents the measurements, that's another
23 parameter because we're going to be providing
24 different measurements and different other
25 types of data, derived measurements, in it.

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2 The R matrix, another matrix, the
3 measurement noise matrix, is another
4 parameter that you can specify that would --
5 you know, could be used to uniquely create
6 this extended Kalman filter. And even
7 initialization of the process of the
8 covariance matrices is also another thing you
9 can do. You can initialize them in a number
10 of different ways. Right?

11 So those are all parameters that,
12 upon utilizing, can make an extended Kalman
13 filter unique to a particular problem.

14 Q. So if I take your sorting algorithm
15 example -- so a function like a sort function
16 takes in variables, and then it runs through
17 a set of calculations and it returns a value.
18 And these variables can change, depending on
19 what you want to sort?

20 A. Yeah.

21 Q. Is the extended Kalman filter
22 framework sort of the same way where it's
23 sort of this box of calculations, and,
24 depending on what you put into it, what you
25 get out is different because what you want to

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 estimate is different, but the calculations
3 themselves --

4 MR. RAFILSON: Objection. Form.

5 BY MR. CHEN:

6 Q. -- are the same?

7 A. Yeah. I mean, you can't quite
8 consider it a black box -- right? -- because
9 the equations themselves have parameters
10 within them, right? So -- but, you know,
11 given the blueprint -- right? -- you can then
12 provide these parameters, and it will provide
13 you with, you know, hopefully reasonable
14 estimates for whatever it is you're trying to
15 estimate.

16 Q. So it's almost like a Kalman filter
17 has nested functions inside that can change
18 depending on which variables you put in
19 there?

20 A. Well, they don't necessarily have
21 nested -- I wouldn't call them nested
22 functions. I'd call them really just -- I
23 mean, as I said, they're parameters. When
24 you think of -- people think of parameters,
25 they often think of numbers. I'm thinking

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2 about, these parameters are not just numbers.
3 They're functions. They're differential
4 equations. There's lots of different
5 components to it.

6 So it's not just a number. There's
7 much more to it than that, right? There's
8 these other pieces that -- and not even that.
9 It's sensors, right?

10 So it's more than just a number.
11 It's -- and certain sensors will, you know,
12 behave differently, and therefore, you have
13 to deal with the way they behave and so on
14 and so forth. So it all kind of plays a role
15 in making that particular extended Kalman
16 filter, you know, unique to what it is trying
17 to estimate.

18 And if that was not the case, then
19 you would not see examples in the literature
20 where people are comparing extended Kalman
21 filters with different parameters and
22 different functions to see if they can get
23 better results for a given problem.

24 Q. So I guess what you would say is
25 that the '438 patent enhanced comparison

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2 method sort of defines a unique type of
3 extended Kalman filter?

4 A. I would say it's -- any embodiment
5 that's being presented in the patent, it's
6 unique, or there are elements of it that are
7 unique.

8 Q. A unique type of extended Kalman
9 filter?

10 A. Yes.

11 Q. And that's because the parameters
12 you plug in are different?

13 A. Well, yeah. I mean, they're -- they
14 can be different depending on what you're
15 trying to do, what you're trying to -- even
16 with the same estimation, if you're still
17 trying to estimate orientation, there are
18 certainly other ways to do it, right? The
19 '978 patent used a magnetometer.

20 Q. Right. But just the '438 patent,
21 the difference is the parameters are
22 different?

23 A. Right.

24 Q. So the '438 patent says I'm going to
25 calculate orientation using the extended

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Kalman filter framework that the parameters
3 that I'm putting in there are different
4 than -- I guess not different. I'm putting a
5 special set of parameters in there?

6 MR. RAFILSON: Objection. Form.

7 A. So you are putting a set of
8 parameters in that may or -- they may or
9 may -- so the other thing that -- about one
10 of these things is that, you know, an
11 extended Kalman filter is that you have these
12 parameters, and, in some cases, you know,
13 some of the parameters may be similar across
14 different extended Kalman filters, and some
15 of them might be different. Right?

16 This particular '438 patent provides
17 a -- or it discloses an embodiment of, you
18 know, one set of parameters for that. But
19 there certainly could be others that could be
20 utilized within this -- within the claims --
21 underneath the claims, I guess I should say.

22 BY MR. CHEN:

23 Q. So what other embodiments does the
24 '438 patent encompass?

25 A. Well --

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 MR. RAFILSON: Objection. Form.

3 A. I mean, I can quote certain parts of
4 the patent which say, according to an
5 exemplary embodiment of the method or an
6 illustrative example of the above, first and
7 second probabilities may be further obtained.
8 So these are all indicating that these are,
9 you know, exemplary embodiments but not
10 potentially the only embodiments that could
11 be -- or methods that someone of ordinary
12 skill in the art could do with the patent
13 that we have in front of us.

14 BY MR. CHEN:

15 Q. I guess I'm trying to ask you what
16 you think the scope of the '438 patent is
17 because we have this general framework, and
18 then we have a set of parameters in Equations
19 1 through 4. What else does the '438 patent
20 disclose?

21 MR. RAFILSON: Objection. Form.

22 The document speaks for itself.

23 A. Well, are you asking me what does
24 the '438 patent disclose specifically related
25 to the extended Kalman filter or related to

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 the claims in general?

3 BY MR. CHEN:

4 Q. Well, let's just take claims -- the
5 asserted claims, which are Claims 1, 14, and
6 19.

7 A. Okay.

8 Q. Those all talk about doing that
9 comparison, and we've talked a lot about the
10 enhanced comparison method in Equations 1
11 through 11. Besides just doing Equations 1
12 through 11, do those claims disclose any
13 other method of calculating orientation?

14 MR. RAFILSON: Objection. Form.

15 Objection. Vague.

16 A. So if you look at Claim 1 -- and you
17 go down to on Column 19 -- it says,
18 "communicating with the six-axis motion
19 sensor module to calculate a resulting
20 deviation," first signal set, second signal
21 set and so on, "wherein the comparison
22 utilized by the processing and transmitting
23 module further comprises an update program to
24 obtain an updated state based on a previous
25 state associated with" the signal sets;

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 "wherein the measured state includes" -- the
3 claims there, I mean, they -- they -- they
4 state, you know, the basic building blocks of
5 the claim in the '438 patent, which the first
6 and second signal set using the update, but,
7 you know, aside from having an accelerometer
8 and a gyroscope in the claim and the enhanced
9 comparison method, the details for some of
10 the parameters and how you use the various
11 things all kind of -- the claim kind of
12 governs a number of possibilities that could
13 be done -- right? -- with this -- with these
14 pieces.

15 So if you assume that Kalman filter
16 -- extended Kalman filter is a framework, you
17 can also assume that Claim 1 is also a
18 framework, but it's a framework that has more
19 pieces in it. Okay? And, ultimately, you
20 could still do different things; you just
21 have more pieces as part of the puzzle.

22 That's the best way to describe what
23 the claim is, especially when it comes to the
24 enhanced comparison method. I mean, you --
25 and the claim doesn't also -- doesn't say

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 anything about not having other things in it,
3 right? I mean, it could have other things in
4 it besides these two sensors. It doesn't say
5 that you have -- that you only can have these
6 two, right? So in that regard, error could
7 be potentially more encompassing. It's less
8 restrictive than more restrictive.

9 BY MR. CHEN:

10 Q. So scopewise, the enhanced
11 comparison method in Claim 1 is everything
12 that uses the angular velocities,
13 accelerations using that extended Kalman
14 filter to calculate orientation, but it can
15 also encompass any other variables that are
16 not disclosed in the claim?

17 MR. RAFILSON: Objection. Compound.
18 Objection. Vague. Objection. Form.

19 A. I mean, it could potentially utilize
20 other -- other elements, quantities. It's
21 possible.

22 BY MR. CHEN:

23 Q. But the enhanced comparison method
24 itself, that's Equations 5 through 11?

25 MR. RAFILSON: Objection. Form.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. The -- the enhanced comparison
3 method technically is described in -- in part
4 by Equations 5 through 11.

5 BY MR. CHEN:

6 Q. And there's certain variables like
7 the noise matrix?

8 A. Yes. There are certain pieces that
9 you would need to have to complete the
10 enhanced comparison method, which the patent
11 does talk about in terms of the sensors that
12 are being used, so on and so forth,
13 measurements, noises, and things like that.

14 Q. But to be clear, it talks about what
15 they are, but a POSITA would have to know
16 because it's not in the patent like how to
17 frame that matrix, how to --

18 A. Yeah.

19 Q. -- create it, basically?

20 A. Uh-huh.

21 MR. CHEN: I'm going to mark 4.

22 (Exhibit Number 4, U.S. Patent

23 Number 8,552,978, was marked

24 for identification.)

25 ///

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. CHEN:

3 Q. So I have just handed you Exhibit 4,
4 and this is the '978 patent; is that correct?

5 A. Yes.

6 Q. What is the '978 patent, which I
7 narrowly discussed?

8 A. It discloses a 3D pointing device.
9 It utilizes an orientation sensor, and,
10 actually, it uses -- utilizes orientation
11 sensor, a accelerometer and a magnetometer to
12 calculate deviation angles, orientation
13 angles of a device.

14 Q. So the '978 patent has a
15 magnetometer?

16 A. Magnetometer.

17 Q. Magnetometer. And that's what makes
18 it different from the '438 patent?

19 MR. RAFILSON: Objection. Form.

20 Objection. The document speaks for
21 itself.

22 A. Yeah, that is the primary difference
23 between the two patents.

24 BY MR. CHEN:

25 Q. Okay. Go to Claim 10, please, and

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 that is on the last page, Column 36 to 37.

3 And could you review that, and just let me
4 know when you're done.

5 A. (Reviewing document.)

6 Okay.

7 Q. And what we're seeing, the '978
8 patent and, more specifically, Claim 10 also
9 recites a 3D pointing device, right?

10 A. Uh-huh.

11 Q. And we've already discussed 3D
12 pointing device, and I believe you testified
13 that a 3D pointing device is any device with
14 sensors that is able to calculate its own
15 orientation; is that correct?

16 MR. RAFILSON: Objection. Form.

17 A. Uh-huh.

18 BY MR. CHEN:

19 Q. Is that yes?

20 A. Yeah, that's correct.

21 Q. Could you take a look at
22 paragraph -- Column 3 in the '978 patent,
23 starting on 63. So Column 3, 63 to 4, 4.
24 And if you want the context, you can read
25 that whole paragraph.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. (Reviewing document.)

3 Okay.

4 Q. And you see that paragraph
5 describing a number of electronic devices; is
6 that correct?

7 A. What number is that? What column?

8 Q. It starts, "In addition, as the
9 trend of 3D technology advances."

10 A. Yes.

11 Q. Actually, could you just read that
12 paragraph for the record, starting --

13 A. "In addition, as the trend of 3D
14 technology advances and is applicable to
15 various fields including displays,
16 interactive systems and navigation, there is
17 a significant need for an electronic device,
18 including, for example, a motion detector, a
19 3D pointing device, a navigation equipment,
20 or a communication device integrated with
21 motion sensors therein, capable of accurately
22 outputting a deviation of such device readily
23 useful in a 3D or spatial reference frame."

24 Q. So this paragraph is talking about a
25 number of devices that can calculate their

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 own orientation; is that correct?

3 A. Yes.

4 Q. And one of those devices is a 3D
5 pointing device?

6 A. That's right.

7 Q. But it also gives other examples
8 like a motion detector; is that correct?

9 A. Uh-huh.

10 Q. And it gives a navigation equipment
11 example?

12 A. Yes.

13 Q. And it gives an example of a
14 communication device integrated with motion
15 sensors?

16 A. Uh-huh. That's correct.

17 Q. So from your definition, what is the
18 difference between a motion detector and a 3D
19 pointing device?

20 MR. RAFILSON: Objection. Form.

21 A. I suppose a motion detector is
22 something that will detect motion of
23 something. 3D pointing device is a device
24 that will calculate orientation so that it
25 can be utilized in a variety of different

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 ways from -- yeah.

3 BY MR. CHEN:

4 Q. This says in the paragraph that
5 there's a number of devices that can
6 accurately calculate their own orientation,
7 and a 3D pointing device is one of them.

8 A. Uh-huh.

9 Q. So, for example, just a
10 communication device integrated with sensors,
11 that can calculate its own orientation?

12 A. Yes.

13 Q. So what's the difference between
14 that and a 3D pointing device?

15 MR. RAFILSON: Objection. Form.

16 A. Well, the 3D pointing device is
17 being used for probably a specific function
18 over the communication device or the motion
19 detector. The motion detector could be
20 simply to detect motion of a person --
21 communication device, so I know something
22 about where the device is located in the
23 world. The difference is 3D pointing device
24 is actually something that's used in the
25 orientation to support a number of

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 activities, including pointing and also
3 understanding -- or providing direction
4 and/or orientation information that can be
5 utilized to render graphical elements on a
6 screen so that they'll move with respect to
7 the device.

8 BY MR. CHEN:

9 Q. Can I turn your attention to
10 Exhibit 2, which is your second declaration.

11 A. Yes.

12 Q. And can you look at paragraph 96 of
13 your second declaration.

14 A. Yes.

15 Q. So in this paragraph, you say, "The
16 '978 patent states 'in order to calculate the
17 resulting deviation, the computing processor
18 348 may utilize" --

19 A. Wait a minute. Wait a minute. Wait
20 a minute. Am I looking at the wrong thing
21 here? You said Exhibit 2?

22 Q. Yeah, the February 23rd.

23 A. Exhibit 2, the 23rd.

24 Q. I think that might be Exhibit 1, or
25 I might have my numbers wrong.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. I have Exhibit 2 dated 2/23/2018,
3 paragraph 96. "However, a person of ordinary
4 skill in the art would recognize that the
5 enhanced comparison method disclosed in the
6 '978 patent is designed to handle noise and
7 errors that would emanate from moving the 3D
8 pointing device."

9 Q. Are you looking at paragraph --

10 A. 96.

11 Q. 96. Yeah. Right. I just went to
12 the second sentence.

13 A. Oh. Okay. '978 states, "In order
14 to calculate" -- okay. Yes.

15 Q. This is talking about using a
16 comparison or algorithm to eliminate the
17 errors of the first, second, and third signal
18 sets. And the first signal set and the
19 second signal set and the third signal set,
20 those are what you get from the rotation
21 sensor, the accelerometer, and the
22 magnetometer?

23 A. It's hard to say, just like
24 "negligible."

25 Q. Magnetometer.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Just a quick correction. The order
3 that is presented in the patent is -- first
4 is accelerometer, second is magnetometer, and
5 third is rotation sensor.

6 Q. Okay. So you use the readings from
7 the sensors, and you utilize the comparison
8 method to eliminate the errors that are kind
9 of inherent in each one of those sensors?

10 A. Uh-huh.

11 Q. And then is that comparison method
12 in Equations 5 through 11 the same equations
13 that we've been talking about?

14 A. Yes.

15 MR. CHEN: Can you guys give me five
16 minutes to check my notes?

17 MR. RAFILSON: Sure.

18 (Break taken from 1:53 p.m. to
19 2:03 p.m.)

20 BY MR. CHEN:

21 Q. So just going back briefly to the
22 '978 patent and this comparison algorithm --

23 A. Yes.

24 Q. -- besides Equations 5 through 11,
25 are there calculations needed to do the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 comparison method disclosed anywhere else in
3 the '978 patent?

4 A. Besides -- okay. So you're asking
5 me is anywhere else besides Equations 5
6 through 11 a disclosure of the enhanced
7 comparison method '978 patent? The answer to
8 that question is, actually, there's a small
9 addition that's somewhat separate from
10 Equations 5 through 11, and they are
11 Equations 26 through 28.

12 So Equations 26 through 28 will
13 provide orientation -- an estimate of
14 orientation based on the accelerometer and
15 the magnetometer, given that the device is
16 stationary. So that, in and of itself,
17 provides an additional component to enhance
18 the comparison method. It's an either/or
19 proposition essentially. You can use this or
20 you can use the enhanced comparison method to
21 get the orientation.

22 Q. It's either/or?

23 A. Well, the problem is, is that if the
24 device is moving -- well, let me put it to
25 you this way: These equations will work if

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 the device is stationary, you know, just
3 holding it like this.

4 Q. And just to clarify, Equations 26
5 through 28?

6 A. Yes.

7 Q. Okay.

8 A. But if the device is moving and/or
9 we want to use the gyroscope, then the
10 enhanced comparison method would include
11 Equations 5 through 11. So the small little
12 addendum to the enhanced comparison method.

13 Q. So this is just in the event that
14 the device is not moving and we don't want to
15 use a gyroscope -- let's just do 26, 27, and
16 28 -- that gives us an estimate of
17 orientation?

18 A. Yes.

19 Q. But if the device is moving or we
20 want to use the gyroscope, we have to go back
21 to that extended Kalman filter --

22 A. Yes.

23 Q. -- in 5 through 11?

24 A. Uh-huh.

25 Q. Is there any other disclosure of the

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 '978 patent's enhanced comparison method in
3 this specification?

4 MR. RAFILSON: Objection. Form.

5 A. Aside from described -- from using
6 the term enhanced comparison method, the
7 various places throughout the patent and
8 describing what it's for and why it's needed
9 and the Figures 7 and 8, no.

10 BY MR. CHEN:

11 Q. So I assume you're being paid an
12 hourly rate for your work?

13 A. Yes, uh-huh.

14 Q. What is that hourly rate?

15 A. 375 an hour.

16 Q. 375?

17 A. Yes. 375, not \$3.75.

18 Q. Do you keep track of the hours you
19 work?

20 A. Yes, I do.

21 Q. Do you know approximately how much
22 time you've spent so far?

23 A. Off the top of my head, I would say
24 maybe 70, 80 hours, something like that, at
25 this point.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 Q. And besides the hourly rate, you're
3 not compensated in any other manner?

4 A. I do get compensated at a lower rate
5 for travel.

6 Q. How much is that?

7 A. 250, maximum of eight hours.

8 Q. And you don't have a financial
9 interest --

10 A. No.

11 Q. -- in CyWee?

12 A. No.

13 MR. CHEN: Pass the witness.

14 MR. RAFILSON: Okay. We'll go on
15 break for a bit.

16 MR. CHEN: Yeah.

17 MR. RAFILSON: Probably be -- I'm
18 not sure exactly how long it'll be. I
19 would assume at least probably -- well,
20 let's just -- we'll check back in about
21 15 minutes, 10, 15 minutes, and we'll
22 let you know.

23 (Break taken from 2:10 p.m. to
24 2:58 p.m.)

25 CROSS-EXAMINATION

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. RAFILSON:

3 Q. Dr. LaViola, thank you for your
4 testimony today. There was -- earlier today,
5 there was testimony about a 3D pointing
6 device and its scope, right?

7 A. Uh-huh.

8 Q. Now, how do you think this term
9 should be construed for the '438 patent?

10 A. So I don't think that it should be
11 construed or needs to be construed. However,
12 if it does -- were to be construed, I would
13 construe it as a handheld device that uses at
14 least the rotation sensor comprising one or
15 more gyroscopes and one or more
16 accelerometers to determine deviation angles
17 or the orientation of a device.

18 Q. And how, if at all, is that
19 different from your testimony earlier?

20 A. It's slightly different. I was not
21 as precise in my definition in my earlier
22 testimony. I stand by my declaration.

23 Q. How do you think the term should
24 be -- the term 3D pointing device should be
25 construed for the '978 patent?

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. In the '978 patent, I don't think it
3 needs to be construed; but if it does, it
4 would be construed as a handheld device that
5 includes at least one or more accelerometers
6 and a magnetometer and, optionally, a
7 rotation sensor comprising one or more
8 gyroscopes and uses them to determine
9 deviation angles or the orientation of a
10 device.

11 Q. Okay. I want to refer you to
12 Exhibit 4. And for the record, what is
13 Exhibit 4 again?

14 A. That's the '978 patent.

15 Q. Okay. And what's the title of
16 the -- of Exhibit 4?

17 A. "3D Pointing Device and Method for
18 Compensating Rotations of the 3D Pointing
19 Device Thereof."

20 Q. And I'd like to refer you to a
21 portion of text counsel referred you to
22 earlier today. Would you turn to the bottom
23 of Column 3 of Exhibit 4.

24 A. Okay. Yes.

25 Q. And do you see the text that refers

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 to a navigation device, motion detector, or a
3 communication device?

4 A. Yes.

5 Q. Would you read that sentence for the
6 record, please.

7 A. Okay. "In addition, as the trend of
8 3D technology advances and is applicable to
9 various fields including displays,
10 interactive systems and navigation, there is
11 a significant need for an electronic device,
12 including, for example, a motion detector, a
13 3D pointing device, a navigation equipment,
14 or a communication device integrated with
15 motion sensors therein, capable of accurately
16 outputting a deviation of such device readily
17 useful in a 3D or a spatial reference frame.

18 Q. Thank you, Dr. LaViola.

19 And how, if at all, is a 3D pointing
20 device different from a navigation device?

21 A. It's not necessarily different.
22 It's -- could be integrated within. In fact,
23 if you look at Figure 6 in the '978 patent,
24 it's a picture of a -- effectively, a
25 smartphone or navigation equipment and was an

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 exploded diagram that shows an embodiment of
3 electronic device, the present invention,
4 such as a smartphone or navigation equipment,
5 utilizing a nine-axis motion sensor module
6 according to another embodiment of the present
7 invention.

8 Q. I'm sorry, Dr. LaViola. What text
9 are you reading?

10 A. This is Figure 6 on the '978 patent,
11 Column 8, row 37 to 43.

12 Q. Okay. How, if at all, is a 3D
13 pointing device different from a motion
14 detector?

15 MR. CHEN: Object to the form.

16 A. It isn't necessarily different from
17 a motion detector. It can be used as a
18 motion detector.

19 BY MR. RAFILSON:

20 Q. How, if at all, is a 3D pointing
21 device different from a communication device?

22 MR. CHEN: Object to form.

23 A. It could be used as a motion -- as a
24 navigation device as well, or included within
25 it.

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 BY MR. RAFILSON:

3 Q. Dr. LaViola, I want to clarify my
4 question. I said, "How, if at all, is a 3D
5 pointing device different from a
6 communication device?"

7 A. Oh, I'm sorry.

8 MR. CHEN: Object to form.

9 A. Yes, it could also be included as
10 part of a communication device as well, 3D
11 pointing device.

12 BY MR. RAFILSON:

13 Q. I'd like to refer you to Equation 11
14 of the '438 patent. That's Exhibit 3. So
15 that is -- look at Column 14, please.

16 A. Yes.

17 Q. There was some testimony about
18 Equation 11 earlier today, right?

19 A. Yes.

20 Q. How, if at all, were you familiar
21 with Equation 11 before this case?

22 A. I was familiar with the general
23 concept of Equation 11 but not the actual
24 equation itself.

25 Q. So we talked earlier about the scope

1 JOSEPH J. LAVIOLA, JR., Ph.D.
2 of the claims. How, if at all, do you
3 believe that the claims require that
4 Equation 11 be used?

5 A. I don't believe that the -- that it
6 requires Equation 11 to be used at all. It
7 can be used -- there are other equations that
8 are similar that can be used in its place to
9 maintain the enhanced comparison method.

10 MR. RAFILSON: Thank you,
11 Dr. LaViola. I have no further
12 questions.

13 REDIRECT EXAMINATION

14 BY MR. CHEN:

15 Q. Dr. LaViola, during the most recent
16 break, did you confer with CyWee's counsel,
17 Ari Rafilson?

18 MR. RAFILSON: I would advise,
19 Counsel, not to disclose the contents of
20 any particular communications.
21 Otherwise, he can discuss generally that
22 we spoke together.

23 MR. CHEN: So you're saying the
24 contents are not discoverable?

25 MR. RAFILSON: That is what I'm

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 saying.

3 MR. CHEN: So you're instructing him
4 not to answer?

5 MR. RAFILSON: No. I'm saying he
6 can disclose generally that we spoke.

7 A. We spoke.

8 BY MR. CHEN:

9 Q. What did you speak about?

10 A. General things related to the
11 deposition.

12 Q. What specifically did you speak
13 about?

14 MR. RAFILSON: Now I'll object to
15 him not to answer.

16 MR. CHEN: So your objection is --
17 you're instructing him not to answer
18 that question?

19 MR. RAFILSON: I'm instructing him
20 not to disclose privileged
21 communications.

22 MR. CHEN: I'd like to preserve on
23 the record that that's an improper --
24 well, from Samsung's perspective, that's
25 an improper objection. That's an

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 improper instruction not to answer, and
3 reserve the right to raise it with the
4 Court later.

5 MR. RAFILSON: Okay.

6 BY MR. CHEN:

7 Q. One final question, Dr. LaViola.

8 If we look at the '438 patent that
9 we just looked at with Ari -- and now we're
10 looking back at Equation 11.

11 A. Yes. Okay.

12 Q. So, previously, I believe you
13 testified that Equation 11 gives you an error
14 or a third quaternion?

15 A. Yes, that's right.

16 Q. And the third quaternion would be
17 sort of the updated state?

18 A. Yeah. That would be the -- the --
19 yeah, the updated state, uh-huh.

20 Q. Sort of like the best guess of
21 orientation?

22 A. Yes.

23 Q. So why isn't it required to use
24 Equation 11?

25 A. Because there are other potential

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 equations that could also be used. It's not
3 necessarily a requirement. This particular
4 equation could be used, but it not
5 necessarily needs to be used.

6 Q. But the other equations that you're
7 talking about, where are they in the '438
8 patent?

9 MR. RAFILSON: Objection. Form.

10 A. Those equations are not in the
11 patent, but the patent states that this is an
12 illustrative example, and anyone of ordinary
13 skill in the art would know that there are
14 other optional equations that could be used.
15 BY MR. CHEN:

16 Q. But the only equation that the '438
17 patent gives you to get the third quaternion
18 or the error is Equation 11?

19 MR. RAFILSON: Objection. Form.

20 A. That is correct.

21 BY MR. CHEN:

22 Q. And the other equations that you
23 were referring to, those would have been
24 well-known in the art at the time of the
25 invention --

1 JOSEPH J. LAVIOLA, JR., Ph.D.

2 A. Yes.

3 Q. -- of the '438 patent, correct?

4 MR. RAFILSON: Objection. Form.
5 Exceeds the scope.

6 A. Uh-huh.

7 MR. CHEN: Okay.

8 MR. RAFILSON: Great.

9 (Concluded at 3:08 p.m.)

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CERTIFICATE OF OATH

STATE OF FLORIDA
COUNTY OF ORANGE

I, the undersigned authority,
certify that JOSEPH J. LAVIOLA, JR., Ph.D.,
personally appeared before me and was duly
sworn.

WITNESS my hand and official seal
this 8th day of March, 2018.

Rhonda Hall-Breuwet, RDR, CRR, LCR, CCR, FPR, CLR
NCRA Realtime Systems Administrator
Notary Public - State of Florida
My Commission Expires: 9/28/19
Commission No. FF 915315

C E R T I F I C A T E

STATE OF FLORIDA:

I, RHONDA HALL-BREUWET, RDR, CRR,
LCR, CCR, FPR, CLR, NCRA Realtime Systems
Administrator, shorthand reporter, do hereby
certify:

That the witness whose deposition is
hereinbefore set forth was duly sworn, and that
such deposition is a true record of the
testimony given by such witness.

I further certify that I am not
related to any of the parties to this action by
blood or marriage, and that I am in no way
interested in the outcome of this matter.

IN WITNESS WHEREOF, I have hereunto
set my hand this 8th day of March, 2018,

RHONDA HALL-BREUWET, RDR, CRR, LCR, CCR, FPR, CLR,
NCRA Realtime Systems Administrator
Shorthand Reporter

ERRATA SHEET

Case Name:

Deposition Date:

Deponent:

Pg.	No.	Now Reads	Should Read	Reason
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SUBSCRIBED AND SWORN BEFORE ME

THIS _____ DAY OF _____, 2018.

(Notary Public) MY COMMISSION EXPIRES: _____

Signature of Deponent

CyWee Group Ltd. v. Samsung Electronics Co., Ltd. et al.
Errata Sheet

Witness: Joseph J. LaViola, Jr., Ph.D.

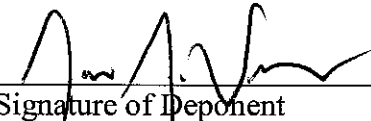
Date of Deposition: March 7, 2018

PAGE /LINE(S)	TEXT AS WRITTEN	CORRECTION	REASON FOR CHANGE
16:25,17:2 -3	In general, it discloses a 3D pointing device and method for compensating movement.	In general, it discloses a 3D pointing device and method for computing its orientation in the presence of noise and errors from its sensors	Witness clarification
18:2-5	3D pointing device is a device that gathers 3D orientation information to support both direction and/or pointing.	For the '438 patent, a 3D pointing device is a handheld device that uses at least a rotation sensor comprising one or more gyroscopes, and one or more accelerometers to determine deviation angles or the orientation of a device. For the '978 patent, a 3D pointing device is a handheld device that includes at least one or more accelerometers and a magnetometer, and optionally a rotation sensor comprising one or more gyroscopes, and uses them to determine deviation angles or the orientation of a device.	Witness clarification
18:20	In general, that is correct.	In general, that is correct so long as the pointing device has the limitations I previously described.	Witness clarification
19:23	Yeah.	Yes, but not 3D pointing devices that include all the limitations of the '438 and '978 patents.	Witness clarification
33:23-25	those could be neg- -- I can't say that word -- negligible.	Those could be negligible	Witness clarification

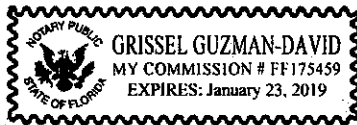
39:20	An Extended Kalman filter, which is described	An optimal estimator, such an extended Kalman filter, which is described	Witness clarification
41:4	which represent an extended Kalman filter	which represent an optimal estimator such as an extended Kalman filter	Witness clarification
44:18	You calculate it – it's actually in	You can calculate it using one of the embodiments in	Witness clarification
46:2-3	three-dimensional vector, and a scale of value to represent an axis and angle.	Three-dimensional vector, and a scalar value to represent an axis and angle	Transcription error
46:24-25	typically, a two-dimensional column	typically rows and columns of a table	Witness clarification
59:4	Uh-huh.	It would have been known, but not well-known.	Witness clarification
59:10	Uh-huh.	It would have been known, but not well-known.	Witness clarification
59:16	(Nods head.)	It would have been known, but not well-known.	Witness clarification
61:25	Yes	It is part of an optimal estimator such as an extended Kalman filter.	Witness clarification
75:10-11	So the function f and the term x minus -- x_{t-1} is generally referring to	So the function f and the term x of t given $t-1$ is generally referring to	Transcription error
79:19	An extended Kalman filter and that there are	An optimal estimator such as an extended Kalman filter and that there are	Witness clarification
79:24	No.	Not with the same degree of specificity.	Witness clarification

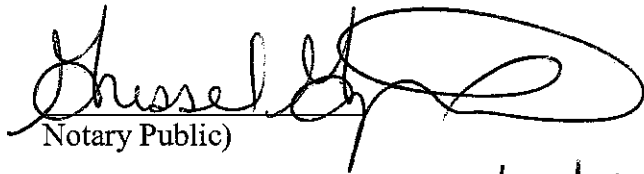
103:5-6	to compare with the measurement, the process model, because it	to compare with the process model because it	Witness clarification
129:14-17	Equation 11 -- is -- Equation 11 is -- it's slightly unclear what Equation 11 is doing. But based on the mathematics in it	Based on the mathematics in Equation 11	Witness clarification
153:23	between the two patents.	between the two patents. Another difference is the transformed output.	Witness clarification
154:17	Uh-huh.	In the context of the '438 patent, a 3D pointing device is a handheld device that uses at least a rotation sensor comprising one or more gyroscopes, and one or more accelerometers to determine deviation angles or the orientation of a device. In the context of the '978 patent, a 3D pointing device is "a handheld device that includes at least one or more accelerometers and a magnetometer, and optionally a rotation sensor comprising one or more gyroscopes, and uses them to determine deviation angles or the orientation of a device."	Witness clarification
154:20	Yeah, that's correct.	In the context of the '438 patent, a 3D pointing device is a handheld device that uses at least a rotation sensor comprising one or more gyroscopes, and one or more accelerometers to determine deviation angles or the orientation of a device. In the context of the '978 patent, a 3D pointing device is "a handheld device that includes at least one or more accelerometers and a magnetometer, and optionally a rotation sensor	Witness clarification

		comprising one or more gyroscopes, and uses them to determine deviation angles or the orientation of a device.”	
157:16-158:7.	Well, the 3D pointing device is being used for probably a specific function over the communication device or the motion detector. The motion detector could be simply to detect motion of a person communication device, so I know something about where the device located in the world. The difference is 3D pointing device is actually something that's used in the orientation to support a number of activities, including pointing and also understanding -- or providing direction and/or orientation information that can be utilized to render graphical elements on a screen so that they'll move with respect to the device	A 3D pointing device may include a navigation system or other device that calculates its orientation; This is shown in the smartphone example of Figure 6, which is a smartphone. But a motion sensor need not detect orientation, and could used to simply to detect motion of a person. The 3D pointing device can provide and use orientation to support a number of activities. Examples include pointing and also understanding -- or providing direction and/or orientation information that can be utilized to render graphical elements on a screen so that they'll move with respect to the device	


Signature of Deponent

SUBSCRIBED AND SWORN BEFORE ME
THIS 6 DAY OF April, 2018.




Notary Public)

MY COMMISSION EXPIRES: 1/23/19