>> WELCOME.
AND I WOULD LIKE TO THANK YOU
FOR HOLDING AND INFORM YOU THAT
YOUR LINES ARE ON MUTE AND IF
YOU WOULD LIKE TO ASK A
QUESTION, PRESS STAR ONE.
THIS IS BEING RECORDED.
AND HE HAS I WOULD LIKE TO TURN
IT OVER TO ALICIA.
YOU MAY BEGIN.
>> HI, I'M FELICIA CIAO, PUBLIC
AFFAIRS OFFICER AT NASA
HEADQUARTERS IN WASHINGTON D.C.
WELCOME TO TODAY'S TELL COMPASS
TO DISCUSS DISCOVERIES FROM
NATIONAL GUARD'S SPACECRAFT.
WE HAVE FOUR PANELISTS, AND
PLEASE NOTE THAT THERE WILL BE A
30 SECONDS DELAY IN THE
STREAMING.
GO TO WWW.NASA.GOV.
EACH PANELIST WILL GET A SHORT
BRIEFING, AND THEM THE
QUESTION-AND-ANSWER SESSION.
QUESTIONS VIA TWITTER USING THE
HASHTAG AT NASA.
WE'LL BE ANSWERING QUESTIONS AT
3 P.M. EASTERN TODAY THROUGH ASK
ME ANYTHING.
FOR MORE INFORMATION, GO TO
WWW.READIT.COM.
IT'S ALSO ON THE PRESS RELEASE.
THIS MEDIA TELECOM WILL BE
LIMITED TO ONE HOUR.
TODAY'S PAM LIFTS, PAUL HURST,
DIRECTOR AT NASA HEADQUARTERS IN
WASHINGTON.
RESEARCHER IN CALIFORNIA.
ANDREW VANDERBERG, NASA FELLOW
AND ASTRONOMER AT THE UNIVERSITY
OF TEXAS AT AUSTIN.
AND JESSE DOB SIN, MISSION
SCIENTIST AT RESEARCH CENTER IN
IT SILICON VALLEY.

WITH THAT, LET'S GET STARTED.
PAUL?
>> THANKS, FELICIA, TODAY WE'RE
GLAD TO BE ANNOUNCING A
DISCOVERY MADE BY SCIENTISTS
ANALYZING THE NASA KEPLER
TELESCOPE.
BY APPLYING AN ADVANCED TYPE OF
MACHINE CALLED A NEURO NETWORK
TO THE DATE, THESE SCIENTISTS
HAVE FOUND FOR THE FIRST TIME AN
8th PLANET IN THE PLANETARY
SYSTEM.
THIS DISCOVERY OF AN 8th
PLANET IN THE KEPLAR 90 SYSTEM
TIES IT WITH OUR OWN SOLAR
SYSTEM FOR HAVING THE MOST KNOWN
PLANETS.
KEPLAR HAS ALREADY SHOWN US THAT
MOST STARS HAVE PLANETS, AND
TODAY IT CONFIRMS THAT STARS
HAVE LARGE FAMILIES OF
PLANETS JUST LIKE OUR SOLAR
SYSTEM.
KELL LAR WAS THE FIRST ON THE
GROUND OR IN SPACE CAPABLE OF
ORBITING PLANETS LIKE STARS.
FIGURE ONE SHOWS SYSTEMS BEING
DEVELOPED FOR LAUNCH THAT WILL
ADVANCE THE SEARCH FOR LIFE
BEYOND EATER.
THE MISSION WILL BE LAUNCHING
NEXT YEAR IN 2018.
AND THE JAMES WEBB TELESCOPE
WILL BE LAW FIRMING THE YEAR
AFTER THAT, IN 2019.
WHEN WE LAUNCH KEPLAR IN 2019,
WE DIDN'T KNOW IF PLANETS OR
STARS WERE COMMON OR RARE.
BECAUSE OF KEPLAR, WE NOW KNOW
THAT ALMOST EVERY STAR IN THE
NIGHT SKY HAS A FAMILY OF
EXOPLANETS ORBITING IT.
THE KEPLAR SPACE TELESCOPE SPENT

FOUR YEARS LOOKING AT 150,000 STARS, 24/67/365.

AND IT LOOKED FOR SMALL REDUCTIONS IN THE STAR'S BRIGHTNESS CAUSED BY ONE OF THE STAR'S PLANETS PASSING IN FRONT OF IT.

AS SPOKEN IN FIGURE TWO, THIS CAUSES A CHARACTERISTIC U-SHAPED DIP IN THE STAR'S LIGHT CURVE, SHOWING THE TIME CHANGE IN THE BRIGHTNESS OF THE STAR.

KEPLAR COMPLETED IT'S FOUR-YEAR MISSION IN 2013, AND SINCE THEN, IT HAS BEEN OBSERVING DIFFERENT PARTS OF THE SKY.

THE ARCHIVED KEPLAR DATA IS A TREASURE TROVE OF SCIENTIFIC DISCOVERIES WAITING TO BE REVEALED.

TODAY'S SUCH ANNOUNCEMENT IS ONE SUCH DISCOVERY.

TODAY'S ANNOUNCEMENT SHOWS WHAT HAPPENS WHEN NEW SCIENTIFIC METHODS ARE APPLIED TO ARCHIVE AL SCIENTIFIC DATA.

THIS DISCOVERY WAS MADE OF CHRISTOPHER SHALLU, A MACHINE EXPERT AT GOOGLE IA.

AND HE HAS ANDREW VANDERBERG, A NASA FELLOW IN THE ASTRONOMY AT THE UNIVERSITY OF TEXAS.

I'M GOING TO TURN IT OVER TO CHRISTOPHER TO PALESTINIAN HOW MACHINE LEARNING WAS USED TO FIND KEPLAR.

>> HI, EVERYONE, I'M CHRISTOPHER SHALLU, A SENIOR RESEARCH SOFTWARE ENGINEER AT GOOGLE AI.

AND I AM GLAD TO EXPLAIN HOW WE DISCOVERED TWO NEW PLANETS.

THE PLANET WE'RE FOCUSING ON TODAY IS CALLED KEPLAR 90I, THE 8th PLANET AROUND THE STAR.

THIS MAKES IT THE 3rd STAR TO
HOST AS MANY PLANETS AS OUR OWN
SOLAR SYSTEM.
WHAT'S DIFFERENT ABOUT THIS
DISCOVERY IS WE USE MACHINE
LEARNING TO HELP IDENTIFY
PLANETS MISS BID PREVIOUS
SEARCHES OF THE KEPLAR DAT A
MACHINE LEARNING IS A WAY TO
TEACH COMPUTERS TO RECOGNIZE
PATTERNS.
IT'S ONE APPROACH TO ARTIFICIAL
INTELLIGENCE, WHICH MEANS IT'S A
WAY TO MAKE COMPUTERS PERFORM
INTELLIGENT TASKS.
THE KEY IDEA IS TO LET THE
COMPUTER LEARN BY EXAMPLE,
INSTEAD OF HUMANS PROGRAMMING
RULES.
FOR EXAMPLE, WE WOULD TEACH A
SYSTEM OF CATS AND DOGS WITH
THOUSANDS OF MINIMALS AND
LETTING IT LEARN FOR ITSELF
WHICH PATTERNS LOOK LIKE CATS
AND WHICH LOOK LIKE DOGS.
OUR IDEA WAS TO TURN THE
TECHNIQUE TO THE SKIES AND TEACH
A MACHINE LEARNING SYSTEM HOW TO
IDENTIFY PLANETS BY FAR AWAY
STARS.
MY RESEARCH IS FOCUSED ON A
PARTICULAR TYPE OF MACHINE
LEARNING CALLED A NEURO NETWORK.
FIGURE THREE SHOWS A DRAMA OF
THE NETWORK THAT IDENTIFIES
IMAGES OF CATS AND DOGS.
A NEURO NETWORK IS LOOSELY
INSPIRED BY THE STRUCTURE OF THE
HUMAN BRAIN.
IT'S MADE UP OF LAYERS OF
NEURONS THAT EACH DO A SIMPLE
COMPUTATION AND PASS INFORMATION
OFF TO THE NEXT LAYER OF
NEURONS.

YOU CAN THINK OF THEM AS
SWITCHES THAT ACTIVATE DEPENDING
ON THE PATHS OF NEURONS THAT
WERE ACTIVATED IN THE PREVIOUS
LAYER.
WITH MANY CONNECTED NEURONS, THE
NEURONETWORK CAN LEARN TO
RECOGNIZE COMPLEX PATTERNS SUCH
AS CATS AND DOGS.
NEURONETWORKS HAVE BEEN AROUND
FOR DECADES, BUT IN RECENT
YEARS, THEY HAVE BEEN
TREMENDOUSLY SUCCESSFUL IN A
WIDE ARRAY OF PROBLEMS.
THEY CAN TRANSLATE LANGUAGES AND
RECOGNIZE HUMAN SPEECH, AND FIEF
IMAGES AND BREAST CANCER TUMORS.
NOW WE'RE SHOWING THAT THEY CAN
IDENTIFY PLANETS AS IDENTIFIED
BY THE KEPLAR SPACE TELESCOPE.
IN FACT, THE NEURONETWORK THAT
WE USE TO IDENTIFY THE PLANETS
IS VERY SIMILAR TO THE NETWORK
THAT WE USE TO CLASSIFY MINIMALS
OF CATS AND DOGS.
AS TECHNOLOGY ADVANCES AND WE
CONTINUE TO COLLECT MORE DATA,
IT WILL BE INCREASINGLY
IMPORTANT TO KEEP PACE WITH THE
DATA AND MAKE MORE DISCOVERIES
THAN BEFORE.
I BECAME INTERESTED IN MYING
NEURONETWORKS TO ASTRONOMY WHEN
IT COLLECTED SO MUCH DATA THAT
IT WAS IMPOSSIBLE FOR SCIENTISTS
TO EXAMINE IT MANUALLY.
INSTEAD, SCIENTISTS SELECTED THE
STRONGEST PLANETS FOR PLANETS
WITH THE MOST ATTENTION.
THE STRONGEST SIGNALS WERE FOR
HUMAN EYES AND TESTS TO IDENTIFY
WHICH SIGNALS WERE CAUSED BY
ACTUAL PLANETS.
THIS PROCESS IS LIKE LOOKING FOR

NEEDS IN A HAY STEC.
SIGNALS FROM THE KEPLER WERE
IDENTIFIED.
AND IF WE WANT TO SEARCH FOR
THEM IN THE WEAKER TELESCOPE, IT
WOULD BE LIKE LOOKING FOR
NEEDLES IN THE LARGER HAYSTACK.
FLURRY TOO MANY WEAK SIGNALS TO
EXAMINE USING THE METHODS.
IT SHINES IN SITUATIONS WHERE
THERE'S TOO MUCH DATA FOR HUMANS
TO EXAMINE THEMSELVES.
ANDREW AND I DEVELOPED A KNEWO
NETWORK THAT CAN IDENTIFY
PLANETS EVEN IF THE SIGNAL IS
VERY WEAK.
TO TRAIN THE NETWORK, WE USED
16,000 KEPLER SIGNALS THAT WERE
THERE ARE EXAMINED BY HUMAN
SCIENTISTS.
AFTER SHOWING THE SIGNALS, IT
LEARNED TO DISTINGUISH PATTERNS
BY OTHER PLANETS FROM PLANETS
CAUSED BY OTHER OBJECTS.
WHEN WE TESTED IT ON SIGNALS
WHICH HAD NEVER BEEN SEEN
BEFORE, IT IDENTIFIED WHICH WERE
PLANETS AND WHICH WERE NOT 96%
PERIOD OF TIME TIME.
WE IDENTIFIED TWO NEW PLANETS IN
A SEARCH OF 670 STARS.
THESE TWO PLANETS HAVE WEAK
SIGNALS THAT WERE MISSED IN ALL
PREVIOUS SEARCHES OF THE STARS.
AS YOU CAN SEE, THE DATA POINTS
ON THESE TWO SIGNALS ARE MUCH
MORE SPREAD OUT THAN THE STRONG
U-SHAPE THAT WE SAW IN FIGURE
TWO.
BUT EVEN THOUGH THE TWO SIGNALS
WERE VERY WEAK, OUR MODEL WAS
HIGHLY CONFIDENT THAT THESE TWO
SIGNALS WERE CAUSED BY ACTUAL
PLANETS.

ONE OF THESE TWO PLANETS IS
CALLED KEPLER AEG.
AND HE HAS IT'S THE 6th PLANET
IN THE SYSTEM.
BUT THE PLANET WE'RE FOCUSING ON
TODAY IS KEPLER 90I, WHICH IS
THE 8th PLANET IN THE SYSTEM,
WHICH BRINGS IT AS OUR OWN SOLAR
SYSTEM.
THIS IS A REALLY EXCITING
DISCOVERY, AND WE CONSIDER IT TO
BE A SUCCESSFUL PROOF XIII USING
NEURONETWORKS TO IDENTIFY
PLANETS.
EVEN IN SITUATIONS WHERE THE
SIGNALS ARE VERY WEAK.
WE HAVE SOME NEW IDEAS FOR HOW
TO IMPROVE OUR NEURONETWORK, AND
ONCE WE DO, WE PLAN TO SEARCH
ALL 150,000 STARS IN THE KEPLER
DATA.
AND WE HOPE TO FIND LOTS OF
NORPLANTS INCLUDING PLANETS
SIMILAR TO THE EARTH.
AND HE HAS NOW I'LL GO TO ANDREW
TO TELL YOU MORE ABOUT THE NEWLY
DISCOVERED CLAN ET.
KEPLER 90I.
>> MY NAME IS ANDREW
VANDENBERG, AND I STUDIED SMALL
PLANETS MOSTLY FROM DATA FROM
KEPLER, AND I'M EXCITED TO TELL
YOU ABOUT THIS COOL DISCOVERY.
I'M GOING TO TELL YOU ABOUT THE
NEW PLANET, KEPLER 90I AND WHAT
WE KNOW ABOUT THE OTHER PLANETS
IN THE SYSTEM.
FIRST, I WOULD LIKE TO DRAW YOUR
ATTENTION TO 5, WHICH SHOWS ON
THE TOP AND THE SOLAR SYSTEM
PLANETS ON THE BOTTOM.
HERE ARE THE DISTANCES SCALED.
BUT THE DISTANCES BETWEEN THE
PLANETS ARE NOT.

IT'S A G ZERO TYPE STAR THAT'S HOTTER AND MORE MASSIVE THAN THE SUN, AND WHICH LIES 2500 LIGHT YEARS AWAY IN THE NORTHERN SKY. BEFORE THIS WORK, WE ALREADY KNEW THAT KEPLER 90 HOSTS PLANETS, AND CLOSE TO THEIR STAR.

THREE PLANETS SMALLER THAN NEPTUNE OR FARTHER OUT, AND OTHERS THE SIZE OF JUPITER. THE NEW PLANET WE FOUND, KEPLER 90I IS THE SMALLEST OF THE BUNCH.

AND ORBITS JUSTIN BIEBER OUTSIDE.

IN THE KEPLER 90 SYSTEM.

KEPLER AND 90I IS NOT A PLACE I WOULD LIKE TO VISIT THOUGH.

THE SURFACE IS LIKELY SCORCHING HOT.

IT HAS AN AVERAGE TEMPERATURE OF ABOUT 800 DEGREES FAHRENHEIT. STILL LOOKING AT FIGURE 5, I WOULD LIKE TO POINT OUT THAT THE PLANETS FOLLOW A PATTERN, AND THEY'RE FARTHER AWAY.

IN OUR OPEN SOLAR SYSTEM, THIS IS OFTEN EVIDENCE THAT OUR OWN PLANETS FORMED IN THE COOLER PART OF THE SOLAR SYSTEM, WHERE WATER AND ICE CAN STAY SOLID AND CLUMP TOGETHER TO MAKE BIGGER PLANETS.

THE EVIDENCE THAT WE SEE AROUND KEPLER 90I IS THE SAME.

I WOULD LIKE TO DRAW YOUR ATTENTION TO FIGURE, WHICH SHOWS THE SCALE ON THE LEFT, ALONG SIZED THE ORBITS OF THE SOLAR SYSTEM ON THE RIGHT.

THE TWO SMALLER PLANETS, KEPLER 90F AND C, AN ORBIT OF 9 DAY.

90I ORBITS THE STAR EVERY 14

DAYS.
AND D, E AND F ORBIT THE STAR
EVERYONE 6 0, 92, AND 100 DAYS.
AND THE TWO OTHER PLANETS, G AND
H, ORBIT EVERY 211 DAYS AND
EVERY 332 DAYS.
AS YOU CAN SEE IN FIGURE 6, AN
INTERESTING FACT ABOUT THE
KEPLER 90 SYSTEM, ALL OF THE
PLANETS ARE SCRUNCHED CLOSE TO
THE STAR.
AND ALL OF THE ONES IN 90 ORBIT
CLOSER TO THE HOST THAN THE
EARTH ORBITS THE SUN.
THEY ARE MORE SPREAD ON YOU THAN
THE PLANETS IN OUR OWN SOLAR
SYSTEM, AND SOMEHOW MIG RATED TO
WHAT WE SEE TODAY.
THE NEXT SLIDE, 7, IS A ZOOMED
OUT VERSION OF THE IMAGE THAT WE
WERE JUST LOOKING AT.
AGAIN, I'M SHOWING THE KEPLER 90
SYSTEM TO KALE ON THE LEFT,
ALONG WITH THE ONES ON THE
RIGHT.
THE SOLAR SYSTEM HAS FOUR
PLANETS RELATIVELY CLOSE TO THE
SUN, AND KEPLER 90I HAS FOUR
PLANETS CLOSE.
THAT MAY NOT BE THE WHOLE STORY.
IT'S POSSIBLE THAT THEY HAVE
MORE PLANETS THAT WE DON'T KNOW
B ON THE LEFT SIDE OF THE
GRAPHIC, I HIGHLIGHTED ORANGE
AND BLUE FROM THE KEPLER 90
SYSTEM.
KEPLER SEARCHED FOR PLANETS
AROUND 90 ONLY IN THE SMALL
ORANGE HIGHLIGHTED REGION IN THE
CENTER.
THE LARGE BLUE HIGHLIGHTED
REGION IS LARGELY UNEXPLORED.
IF PLANETS DO EXIST, THEY
PROBABLY, THERE'S A LOT OF

UNEXPLODE REAL ESTATE IN THE
KEPLER 90 SYSTEM, AND IT WOULD
BE SURPRISING TO ME IF THERE
WEREN'T MORE PLANETS AROUND THIS
STAR.
IN FIGURE, I'M SHOWING ALL KNOWN
PLANETARY SYSTEMS WITH ONE
PLANET, TWO.
EACH DOT REPRESENTS PLANET
SYSTEMS, AND WE KNOW THAT THEY
ARE AT THE BOTTOM OF THE SYSTEM
AND PROGRESSIVEY FEWER AS WE
INCREASE ALL THE WAY UP TO
KEPLER 09 AT THE STOP DRAMA.
THE ONLY 8th PLANET SYSTEM
OUTSIDE OF OUR OWN.
90 IS THE FIRST WITH 8 PLANETS
BUT ALMOST CERTAINLY WILL NOT BE
THE LAST.
I EXPECT THAT MANY OF THESE
SYSTEMS HAVE MORE UNDISCOVERED
PLANETS WHICH WE HAVEN'T SEEN
YET.
WHEN I THINK ABOUT THIS, I START
TO WONDER, IS AN 8th PLANET
SYSTEM LIKE OUR OWN REALLY THAT
EXTRAORDINARY?
FOR THE 6th TIME SINCE OUR
PLANETS SOLAR SYSTEM WAS
DISCOVERED, WE KNOW FOR SURE,
OUR SOLAR SYSTEM IS NOT THE SOLE
RECORD SYSTEM FOR EIGHT PLANETS,
THEY MAKE OURS SEEM ORDINARY
JEFF WILL TELL US ABOUT THE
IMPACT ON THE PLANETS AND WHERE
WE MIGHT GO FROM HERE.
>> THANK YOU, ANDREW, I'M JESSE
DOTSON, THE PROJECT SCIENTIST
FOR NASA'S T WE HAVE COME A LONG
WAY SINCE THE KEPLER WAS
LAUNCHED 8 AND A HALF YEARS AGO.
AS SHOWN IN FIGURE NINE, AT THAT
TIME, WE KNEW OF 326 EXOPLANETS,
MOST OF WHICH WERE THE SIZE OF

JUPITER, AND MUCH, MUCH LARGER
THAN OUR EARTH.
TODAY, AS SHOWN IN FIGURE TEN,
WE KNOW OF 3,500 CONFIRMED
EXOPLANETS, AND 200 OF THOSE
WERE FOUND IN DATA FROM OUR
TELESCOPE.
THESE RANGE FROM SIZE FROM
LARGER THAN JUPITER TO SMALLER
THAN EARTH.
AND HE HAS IN JUST TWO DECADES,
WE HAVE GONE FROM EXPECTING THAT
EXOPLANETS EXISTED TO KNOWING
THAT THEY EXIST IN OUR GALAXY.
THESE USUALLY INVOLVE NEW TYPES
OF OBSERVATIONS AND NEW WAYS OF
INTERPRETING THOSE OBSERVATIONS.
THE KEPLER DRIVEN REVOLUTION,
AND KNOWING HOW COMMON THE
EXOPLANETS ARE IS FACILITATED
WITH BOTH OBSERVATIONS PERFORMED
BY THE KEPLER SPACE TELL COPE.
AND HE HAS BY SIGNIFICANT
IMPROVEMENTS IN OUR ABILITY TO
INTERPRET THE RESULTING DATA.
THE RESULTS WE'RE DISCUSSING
TODAY DEMONSTRATE THAT WHILE
DATA COLLECTION OF THE ORIGINAL
FIELD IN 2013 ADVANCES
ALGORITHMS TO PROCESS THAT DATA
ARE CONTINUING TO YIELD PROGRESS
AND PLANETARY SYSTEMS AROUND
OTHER STARS.
THE DISCOVERY OF AN 8th PLANET
IN THE KEPLER 90 SYSTEM IS THE
RESULT OF A RESULT OF AN 8th
RESEARCH TO APPLY TO THAT DATA
SET.
BEFORE CHRIS AND ANDREW'S WORK,
KEPLER 90 WAS TIED WITH THE
SYSTEM.
AND NOW IT TIES OUR OWN SOLAR
SYSTEM FOR THE MOST KNOWN
PLANETS, WHILE OUR SOLAR SYSTEM

AND THESE OTHER TWO EACH HAVE
SEVEN TO EIGHT PLANETS,
DIFFERENCES IN THE HOST STARS,
IN THE PLANETS AND LENGTH OF THE
PLANETS CLEARLY DEMONSTRATE THE
DIVERSITY OF PLANETARY SYSTEMS,
AND I'M SO EXCITED TO SEE WHERE
THIS GOES NEXT.
AS THE APPLICATION OF NEURO
NETWORK OCCURS, WHO KNOWS WHAT
POTENTIAL INSIGHTS MIGHT BE
GAINED.
IN ADDITION, NASA CONTINUES TO
USE THE KEPLER TELESCOPE FOR THE
SOLAR SYSTEM.
TO DATE, WE HAVE OBSERVED
200,000 STARS AND 1,000 DEGREES
ON THE HE CLIP TICK PLAIN.
I'M ON THE EDGE OF MY SEAT TO
SEE WHAT CHRIS AND ANDREW MIGHT
LEARN WHEN THEY TURN THEIR
ALGORITHMS TO THOSE REGIONS OF
THE STY ALSO, AND LOOKING
FURTHER INTO THE FUTURE,
COMBINING SOPHISTICATED
ALGORITHMS LIKE THOSE CHRIS AND
ANDREW HAVE DEVELOPED WITH THE
FUTURE MISSIONS THAT NASA HAS
PLANNED IS SURE TO YIELD
EXCITING RESULTS, WHICH WILL
CONTINUE TO ILLUMINATE THE
NATURE OF PLANETARY SYSTEMS, AND
HOW THERE ARE OTHER SYSTEMS
COMPARED TO OUR OWN.
>> THANKS, AND WITH THAT, WE'LL
START THE QUESTION-AND-ANSWER
SESSION.
WE HAVE REPORTERS ON THE
TELEPHONE BRIDGE TODAY.
AND WE'LL NEED TO LIMIT EVERYONE
TO ONE QUESTION AND ONE
FOLLOWUP.
ONCE EVERYONE HAS HAD A CHANCE
AT A QUESTION, IF TIME PERMITS,

WE'LL START AT THE BEGINNING
AGAIN, OUR OPERATOR WILL
IDENTIFY YOU AND DIRECT IT TO A
SPECIFIC PANELIST IF POSSIBLE.
FOR THOSE DIALING IN, PRESS THE
STAR 1 KEY ON YOUR TELEPHONE TO
BE PLACED IN THE QUEUE.
VIA TWITTER, SEND YOUR QUESTIONS
TO THE HASHTAG AT NASA.
AND WITH THAT, LET'S GO AHEAD
WITH MARSHA DUNN.
>> YES, CAN YOU HEAR ME.
>> YES, I CAN.
DR. HURST PROBABLY, WHAT DO YOU
THINK THE ODDS WOULD BE OF
KEPLER EVER HAVING DISCOVERED
THIS EIGHTH PLANET, DO YOU THINK
IT WOULD HAVE TAKEN YEARS MORE,
IF AT ALL?
AND FOR MR. VANDENBERG; YOU SAID
THAT YOU WANT TO IDENTIFY ALL OF
THE STARS IDENTIFIED BY KEPLER
TO DATE.
HOW LONG OF A PROCESS WILL THAT
TAKE YOU AS OPPOSED TO THE
OLD-FASHIONED WAY?
>> MARSH A. I'M GOING TO LET
CHRIS ANSWER BOTH PARTS OF THAT
QUESTION, BECAUSE I'M SURE THAT
HE HAS AN ASSESSMENT OF WHETHER
THIS PLANET COULD HAVE BEEN
FOUND WITH THE AI TECHNIQUES.
>> HI, THIS IS CHRIS.
YES, IT WAS POSSIBLE TO SEE THIS
PLANET ONCE WE HAD IDENTIFIED
THE PLANET WITH THE MODEL.
THE KEY PART OF THIS IS THAT THE
MACHINE LEARNING MODEL WAS
SIMPLY ABLE TO LOOK AT MORE
SIGNALS THAN IT WOULD BE
REASONABLY POSSIBLE TO EXPECT
HUMANS TO LOOK AT.
SO YES, IF HUMANS WERE TO HAVE
LOOKED AT A MUCH LARGER SET OF

SIGNALS, IT WOULD HAVE BEEN
POSSIBLE TO FIND THIS PLANET
USING THE PREVIOUS TECHNIQUES.
BUT AS I MENTIONED, HUMANS HAD
ALREADY EXAMINED 30,000 STRONG
SIGNALS.
AND SO IF THE THEY HAD TURNED TO
THE EVEN WEAKER SIGNALS, THEY
WOULD HAVE HAD TO SEARCH A MUCH,
MUCH LARGER NUMBER OF SIGNALS IN
ORDER TO FIND THIS KEPLER 90I
PLANET.
SO KEY CONTRIBUTION OF MACHINE
LEARNING WAS IT WAS ABLE TO
SEARCH A MUCH LARGER NUMBER OF
SIGNALS THAN HUMANS WOULD HAVE
BEEN ABLE TO DO IN A REACH
AMOUNT OF TIME.
THAT QUESTION, PLEASE?
>> I THINK THAT YOU MENTIONED
THERE WERE I DON'T KNOW, 390
STARS IDENTIFIED BY KEPLER AS
SOLAR SYSTEMS, AND HOW LONG DOES
IT TAKE YOUR MACHINE TO GO
THROUGH THOSE VERSUS THE
OLD-FASHIONED WAY?
>> YEAH, OKAY.
SO SO I DON'T REMEMBER THE EXACT
NUMBERS OFF THE TOP OF MY HEAD,
BUT I BELIEVE WE WERE TAKING
ABOUT 5-6 HOURS TO SEARCH EACH
OF THE STARS IN THE 670 STARS
THAT WE SEARCHED IN THIS
PROJECT.
SO ACTUALLY, THAT PROCESS IS
WHERE WE RUN SOME COMPUTER
SOFTWARE THAT'S NOT A MACHINE
LEARNING MODEL.
AND HE HAS WE ASK IT TO DETECT
SIGNALS ON THE STAR, AND SO THIS
IS THE SAME TECHNIQUE THAT WAS
PREVIOUSLY USED.
AND HE HAS PREVIOUSLY, THAT
SOFTWARE WAS ONLY OUTPUTTING THE

STRONGEST SIGNAL FOR HUMANS TO
EXAM INBY EYE.
AND WHAT WE'RE DOING WHEN WE RUN
THIS SOFTWARE, WE'RE ASKING IT
TO OUTPUT THE WEAKER SIGNALS.
AND SO IN OUR EARLY TESTS ON 670
STARS, IT HAS BEEN TAKING US
ABOUT FIVE TO SIX HOURS PER STAR
TO RUN THAT INITIAL ALGORITHM TO
ACTUALLY DETECT THE CANDIDATES,
BUT ONCE WE HAVE THE CANDIDATES,
IT'S VERY VERY FAST
COMPARATIVELY TO RUN THE MACHINE
LEARNING MODEL AND ASK IT WHICH
OF THOSE CANDIDATES ARE MOST
LIKELY TO BE PLANETS.
>> AND LASTLY, IS THIS LATEST
DISCOVERY, IS IT A CANDIDATE, OR
IS IT CONFIRMED?
HOW ARE YOU CHARACTERIZING IT?
>> I THINK I'LL LET ANDREW TAKE
THIS ONE.
>> HI, THIS IS ANDREW.
WE HAVE STATISTICALLY VALIDATED
THIS CANDIDATE.
AFTER WE IDENTIFIED IT WITH OUR
MACHINE LEARNING METHODS, WE
WENT IN AND VERY CAREFULLY
EXAMINED THE DATE A. AND MADE
SURE THAT THERE ARE NO FALSE
POSITIVE SCENARIOS THAT WERE
CREDIBLE.
AND HE HAS WE USED PREVIOUS
METHODS, INCLUDING WHAT HAS BEEN
USED FOR LARGE CUP LAR RELEASEES
IN THE PAST, CALLED VALIDATION
BY MULTIPOLICETY AND STICKY CALL
VALIDATION FOR THIS TO BE A
EXOPLANET.
1,000 PROBABILITY.
>> NEXT, WE HAVE DAVE.
>> THANK YOU FOR TAKING MY
QUESTION.
I WANT TO SPRING OFF OF MARSHA'S

QUESTION ABOUT THE CONFIRMED
VERSUS CANDIDATES, AND WHAT
TOTAL ARE REAT NOW FOR KEPLER IN
TERMS OF THE PLANETS THAT IT HAS
FOUND.
AND HE HAS I HAVE ANOTHER
INTERESTING QUESTION, THIS IS
ONE FOR CHRIS, AND THIS IS A
FORM OF OUGHT NATION, AND I
GUESS I WOULD AND WOULD THIS PUT
ANY ASTRONOMERS OUT OF WORK OR
HAVE THE INVERSE AFFECT?
>> THIS IS JESSE AND I WOULD
LIKE TO JUMP IN FOR JUST A
SECOND, SO FOR KEPLER, WE'RE AT
5,322 PLANETS THAT HAVE BEEN
OBSERVED BY THE KEPLER
SPACECRAFT.
THE ORM FIELD AND THE ORIGINAL
FIELD IN THE ECLIPTIC.
>> THIS IS A FORM OF AUTOMATION,
AND WE'RE SEEING MORE OF THESE
PROCESSES POP UP.
AND I GUESS I'M ASKING, WILL
THIS PUT ANY ASTRONOMERS OUT OF
WORK, OR WORK ALONGSIDE OF THEM?
>> I CAN ANSWER THAT ALSO.
THIS WILL WORK ALONGSIDE OF
ASTRONOMERS, AND IN A VERY REAL
SENSE, THE WORK THAT WE DID AT
NASA TO LEARN HOW TO VET A
SIGNAL AND IDENTIFY WHAT IS
LIKELY TO BE A PLANET AND WHAT
IS LIKELY TO BE A FALSE
POSITIVE, CHRIS AND ANDREW
TRAINED THEIR MACHINE LEARNING
BASED ON THE CLASSIFICATIONS
THAT HUMAN ASTRONOMERS MADE.
YOU HAVE TO TAKE THEM WITH THE
MACHINE LEARNING AND THEN IT CAN
GO TO A LOT MORE SIGNALS THAN
HUMANS CAN.
DID I GET THAT RIGHT, CHRIS?
>> YES, THANKS FOR THE QUESTION,

I AGREE WITH WHAT JESSE SAID.
AND HE HAS THE LAST THING, WHAT
WE HAVE DEVELOPED HERE IS A TOOL
TO HELP ASTRONOMERS HAVE MORE
IMPACT.
AND HOPEFULLY, THIS IS A WAY TO
INCREASE THE PRODUCTIVITY OF
ASTRONOMERS.
AND HE HAS IT CERTAINLY WILL NOT
REPLACE THEM AT ALL.
IN FACT, I HOPE THAT THIS MAY
PERHAPS GIVE PEOPLE MORE OF A
REASON TO GO INTO ASTRONOMY AND
TO USE ADVANCED TECHNOLOGIES
LIKE THIS IN THE FUTURE.
>> OKAY, THANK YOU.
NEXT WE HAVE MIKE WALL FROM
STAKES.COM.
>> THANK YOU, YOU GUYS.
I HAVE A COUPLE FOR ANDREW
PROBABLY, COULD YOU JUST TALK A
LITTLE BIT ABOUT WHAT KEPLER AAG
IS PROBABLY LIKE, IF IT'S EARTH
SIZE OR THERE ABOUT, AND THEN
THE WHOLE KEPLER 90 SYSTEM, IT'S
SO STRANGE THAT EVERYTHING IS SO
SQUISHED WITH THAT STAR, AND
COULD YOU TALK ABOUT WHAT THAT
MIGHT BE?
THANK YOU.
>> SURE.
SO THE FIRST QUESTION WAS ABOUT
THE OTHER PLANET, WHICH WE
DISCOVERED AND VALIDATED, KEPLER
80G.
AND I LIKE THIS PLANET.
IT HAS A LOT OF REALLY COOL
CHARACTERISTICS, AND SO THIS IS
A PLANET IN ABOUT THE SAME ASHIT
AL PERIOD AS 09I.
IT HAS AN ORBITAL PERIOD OF 5
AND A HALF DAYS, AND IT WAS A
PREVIOUSLY KNOWN 5-PLANET
SYSTEM.

THE STAR IS A REDDER STAR, AND
IT'S CLOSER TO A M TYPE AS FAR,
MAYBE A CAVE DWARF, AND END
DWARF, AND IT HAS AN INTERESTING
CHARACTERISTIC THAT FIVE OUT OF
THE SIX KNOWN PLANETS, INCLUDING
THIS NEW PLANET APPEARED TO BE
LOCKED TOGETHER IN A RESIDENT
CHAIN, AND THIS MEANS THAT THE
MUTUAL GRAVITATIONAL
INTERACTIONS BEEN THE PLANETS
ARE CLOSELY ALIGNED WITH ONE
ANOTHER, FOR LACK OF A BETTER
WORD MUCH THE INTERESTING THING
ABOUT THIS, WE COULD ACTUALLY
HAVE PREDICTED WHAT THE ORBITAL
PERIOD FOR THE NEW PLANET IS
BEFORE WE FOUND IT, BASED ON
SOME MATHEMATICAL RELATIONSHIPS
THAT WERE FIRST WORKED OUT
CENTURIES AGO, AND IF WE USED
THOSE PREDICTIONS, WE WOULD HAVE
PREDICTED THE ORBITAL PERIOD TO
WITHIN ABOUT 2 MINUTES OF WHAT
WE ACTUALLY MEASURED AND SO
THAT'S LIKE MEETING SOMEONE, AND
PREDICTING WHAT THEIR SIBLING
HEIGHT IS TO ABOUT THE PRECISION
OF THE WIDTH OF A HUMAN HAIR.
AND I BELIEVE YOUR SECOND
QUESTION WAS ABOUT WHETHER
KEPLER 90 SYSTEM IS DYNAMICALLY
STABLE.
IT IS WEIRD THAT KEPLER 90 IS
ONE OF THE SQUISHED COMPACT
SYSTEMS, BUT IT'S ACTUALLY NOT
THAT UNCOMMON.
IN KEPLER DATA, WE SEE THIS
QUITE A BIT.
THERE ARE MANY SYSTEMS THAT ARE
MUCH MORE TIGHTLY PACKED THAN
OUR OWN SOLAR SYSTEM.
AND HE HAS THEY SEEM TO BE
DYNAMICALLY STABLE.

SO IT WILL PROBABLY LAST FOR
QUITE THE LONG HAUL.
>> GREAT.
THANK YOU.
>> OKAY, SO BEFORE WE GO BACK
TO THE PHONE LINES FOR MORE
QUESTIONS, WE'RE GOING TO ANSWER
QUESTIONS VIA SOCIAL MEDIA.
WE HAVE A QUESTION HERE, AND
WHAT OTHER AREAS OF SPACE
EXPLORATION DO YOU THINK THAT
MACHINE LEARNING CAN BE APPLIED
TO?
I THINK THIS WOULD GO TO CHRIS
AND MAYBE ANDREW.
>> I CAN START TALKING A LITTLE
BIT ABOUT THIS ONE.
CHRIS AND I HAVE BRAINSTORMED
ABOUT WAYS THAT WE MIGHT USE
MACHINE LEARNING IN ASTRONOMY,
BUT I THINK THAT IT CAN BE USED
IN DIFFERENT WAYS THAT PEOPLE
HAVE TO DO REPEATEDLY WITH A
COMPUTER.
SO YOU CAN IMAGINE THAT OTHER
TYPES OF MISSIONS, FOR EXAMPLE
MICROLENSING PLANET SEARCHES
COULD USE MACHINE LEARNING TO
IDENTIFY PLANETS IN THOSE DATA
SUBS AS WELL.
WE HAVE ALSO THOUGHT ABOUT USING
MACHINE LEARNING TO TRY TO GET
BETTER MEASUREMENTS OF RADIOLOGY
VELOCITY STARS.
HOW QUICKLY THEY'RE MOVING AWAY
FROM US SO WE CAN DETECT PLANETS
USING THE WOBBLE METHOD.
>> THANKS, AND SOME OF THE
SIMILAR QUESTIONS FROM GARY
BRYANT, WHAT PROCESSING SPEEDS
ARE THE COMPUTERS THAT RUN THE
AI TECHNIQUE, AND HOW LONG DID
IT TAKE FOR THIS ALGORITHM TO
COMB THROUGH THE EXISTING DATA?

>> YES, THIS IS CHRIS, AND I'LL
TAKE THIS QUESTION.
SO ACTUALLY, I MENTIONED THE
TRAINING SET, WHICH IS THE
NUMBER OF ALREADY LABELED
SIGNALS THAT WE TRIED THE NEURAL
NETWORK ON CONTAIN 50,000
EXAMPLES PREVIOUSLY LABELED BY
HUMAN SCIENTISTS, BUT ACTUALLY,
AT THE LEVEL OF MACHINE
LEARNING, THIS IS ACTUALLY A
REALLY SMALL TRAINING SET.
TYPICALLY, WE DEAL WITH MODELS,
WHICH HAVE AT LEAST BILLIONS OF
TRAINING EXAMPLES.
SO THIS WAS ACTUALLY A PRETTY
SMALL AND EASY MODEL TO TRAIN.
IN FACT, IT ONLY TAKES ABOUT 2
HOURS TO TRAIN THIS MODEL ON A
REGULAR DESKTOP COMPUTER.
AND I MIGHT ADD TO THIS, WE
BUILT THIS MODEL AND TRAINED
THIS MODEL USING INTENSA FLOW,
AN OPEN SOURCE MACHINE LEARNING
SOFTWARE LIBRARY.
AND THAT WAS PRODUCED BY GOOGLE.
AND WE WILL ACTUALLY BE
RELEASING ALL OF THE CODE NEEDED
TO PROCESS THE DATA AND TRAIN
THIS MODEL IN INTENSA FLOW.
WE'LL BE RELEASING IT SOON, AND
ANYBODY IT COME IN WITH ANY
SPECIALIZED HARDWARE OR
ANYTHING, WE'LL BE ABLE TO TRAIN
THE EXACT SAME MODEL THAT WE
TRAINED, AND POTENTIALLY ALSO
RUN THEIR OWN SEARCHES WITH THE
KEPLER DATA IF THEY SO DESIRE.
AND THEY SHOULD BE ABLE TO DO
THIS WITH OUT ANY SPECIALIZED
HARDWARE.
>> AND JUST TO PIGGYBACK ON
THAT, THIS IS JESSE FROM NASA.
ALL OF THE DATA FROM THE KEPLER

MISSION IS AVAILABLE.
ANYBODY WHO WANTS TO CAN GO TO
THE NASA ARCHIVES AND DOWNLOAD
IT, AND COMBINE THAT WITH THE
TOOLS THAT CHRIS IS ABOUT TO
RELEASE.
>> THANK YOU.
WE'RE GOING TO GO BACK TO THE
PHONE LINES.
NEXT, WE HAVE NICHOLAS ST. CLARE
FROM THE "NEW YORK TIMES."
>> HI THERE, YES, AND THANK YOU
FOR TAKING MY QUESTION.
I HAVE A FUN ONE FOR YOU GUYS
HERE.
SO AS YOU WERE ANNOUNCING YOU
FOUND THIS EIGHT PLANET IN THE
KEPLER 90 SYSTEM, AND OUR SOLAR
SYSTEM HAS EIGHT PLANETS AS
WELL, AND IT'S AN INTERGALACTIC
TIE HERE.
BUT AS YOU'RE AWARE, ASTRONOMERS
ARE INVESTIGATING WHETHER THERE
MIGHT BE A 9th PLANET IN OUR
SOLAR SYSTEM, AND DOES THIS SET
OFF KIND OF A RACE HERE, WHO CAN
FIND THE 9th PLANET FIRST,
BETWEEN KEPLER 90 AND OUR SOLAR
SYSTEM?
>> THIS IS JESSE AND ANDREW CAN
FILE ON AFTERWARDS.
THIS IS A FASCINATING TOPIC, AND
TO ME THIS IS LIKE WATCHING
SCIENTIFIC DISCOVERY IN ACTION.
SO THE NINTH PLANET IS A THEORY
THAT EXPLAINS SOME UNUSUAL
ORBITS THAT WE'RE SEEING IN
DWARF PLANETS AND SOLAR SYSTEM
BODIES OUT IN THE OUTER SOLAR
SYSTEM.
SO IT'S EXPECTED THAT IT MIGHT
BE THERE, BUT WE HAVE NO
DEFINITE PROOF.
SIMILARLY, AS ANDREW TALKED

ABOUT, THERE'S A HUGE PART OF
THE PLANETARY SYSTEM AROUND
KEPLER 09 THAT WE HAVEN'T
SEARCHED YET.
SO IT'S KIND OF COOL TO SEE
WHICH ONE IS GOING TO BE PROVEN
NEXT.
>> THANK YOU, NEXT, WE HAVE
ROBERT BURGER FROM POPULAR
SCIENCE MAGAZINE.
>> YEAH, HI.
I'M WONDERING, NOW THAT WE SEE
AI NETWORKS MAKING DISCOVERIES
LIKE THIS, DOES THIS SPELL THE
END OF CITIZEN SCIENCE?
PROJECTS LIKE UTOPIA AND THE
PLANET HUNTERS?
DOES THIS MEAN THAT WHY USE
SCIENTISTS WHEN YOU CAN TRAIN
THEIR OWN NETWORK TO DO THE JOB
BETTER AND FASTER.
>> THIS IS ANDREW, AND I WORK
QUITE A BIT WITH CITIZEN
SCIENTIST.
AND HE HAS THEY'RE ABSOLUTELY
FANTASTIC.
ONE OF THE THINGS THAT THEY
EXCEL AT FINDING THINGS THAT ARE
WEIRD OR THINGS THAT DON'T LOOK
LIKE THINGS DID BEFORE.
AND AS I UNDERSTAND IT,
NEURONETWORKS STRUGGLE WITH
THAT.
IF YOU SHOW A NEURAL NETWORK
SOMETHING THAT IT HAS NOT SEEN
BEFORE, THEY DON'T KNOW WHAT TO
DO WITH IT, BUT CITIZEN
SCIENTISTS CAN MAKE UNUSUAL
TRANSIT.
A COUPLE OF MONTHS AGO, WE
WORKED ON A RESULT WHERE A
CITIZEN SCIENTIST IDENTIFIED A
TRANSIT IN COMETS, AND HE
IDENTIFIED THEM AS UNUSUAL

BECAUSE OF THEIR SHAPE.
THEY DIDN'T LOOK LIKE NORMAL
TRANSIT.
I'M NOT SURE HOW A NEURAL
NETWORK WOULD HAVE BEEN ABLE TO
LOOK AT SOMETHING THAT SIZE.
AND CHRIS CAN TALK ABOUT IT IF
HE WANTS TO.
>> THIS IS CHRIS, AND I WOULD
LIKE TO ADD ONTO THAT.
I AGREE WITH ANDREW'S POINTS
THERE, AND IT'S ALSO TRUE THAT A
NEURAL NETWORK IS GOOD AT
IDENTIFYING THINGS THAT IT HAS
SEEN BEFORE.
AND HE HAS TYPICALLY, IT NEEDS
TO SEE THEM QUITE A FEW TIMES
BEFORE IT CAN LEARN EXACTLY WHAT
IT'S LOOKING AT.
SO TO ANDREW'S POINT, IT'S GOING
TO TO BE DIFFICULT FOR A NEURAL
NETWORK TO IDENTIFY THESE OTHER
REALLY INTERESTING THINGS THAT
IT CITIZEN SCIENTISTS ARE
COMINGS WITH, AND ALSO TO BRING
BACK TO MY PREVIOUS POINT, I
ALSO HOPE THAT THIS MAY BRING IN
SOME NEW CITIZEN SCIENTISTS WITH
MORE OF A BACKGROUND IN MACHINE
LEARNING, OR WE'LL SORT OF
ENCOURAGE THEM TO TRY TO USE
MACHINE LEARNING IN THEIR
EFFORTS AS WELL.
>> THANK YOU SO MUCH.
>> THANK YOU.
AND BEFORE WE GO BACK TO THE
PHONE LINES, WE'RE GOING TO
ANSWER QUESTIONS ON SOCIAL
MEDIA, THIS IS PROBABLY FOR
CHRIS OR ANDREW.
CAN YOUR ALGORITHM DETECT
ANYTHING DEEPER OTHER THAN IT'S
AN EXOPLANET AND WHICH PLANETS
MAY HAVE LIFE?

>> THIS IS CHRIS, ACTUALLY, OUR CURRENT VERSION OF OUR MODEL, WE INPUT A CANDIDATE SIGNAL, AND WHAT WE GET OUT IS THE PROBABILITY THAT THE MODEL BELIEVES THAT THIS SIGNAL IS A PLANET.
AN ACTUAL PLANET AS OPPOSED TO SOME OTHER SIGNAL THAT COULD HAVE OCCURRED.
SO FOR EXAMPLE, WITH THE NEWLY DISCOVERED PLANET, KEPLER 90I, WHEN WE FED THE SIGNAL INTO OUR COMPUTER, WHAT IT FED OUT WAS IT WAS HIGHLY CONFIDENT THAT THIS PLANET WAS A REAL PLANET.
BUT THAT'S THE SOLE OUTPUT OF THIS NOW.
WHAT WE'RE DOING IN THE FUTURE IS ASKING IT TO OUTPUT PERHAPS MORE FINE GRAINED CHARACTERIZATION, SO IF THE MODEL SHOULD OUTPUT THE PROBABILITY THAT IT'S A PLANET, IF IT'S NOT A PLANET, IT SHOULD ALSO OUTPUT THE PROBABILITY THAT IT'S A BINARY STAR, OR SOME SORT OF OTHER TYPE OF FALSE POSITIVE.
SO WE HAVE PLANS TO ADD SORT OF THAT EXTRA LAYER OF OUTPUT TO THE MODEL IN THE FUTURE.
>> HI, THIS IS ANDREW, AND I WOULD ALSO LIKE TO JUMP IN AND SAY, IT WOULD BE I DON'T THINK WITH KEPLER DATA ALONE WE CAN SAY ANYTHING ABOUT THE PRESENCE OF LIFE ON MY ANY PLANET.
THAT WOULD REQUIRE FUTURE MIGS, LIKE THE JAMES WEB TELESCOPE, WHICH CAN GO IN AND STUDY THESE PLANETS AND THEY CAN IDENTIFY THE FEATURES OF THE PLANETS.
KEPLER IS JUST LOOKING TO SEE IF THE PLANETS ARE THERE, AND

SEARCHING FOR BIO SIGNATURES
WILL HAVE TO BE DONE WITH A MORE
SOPHISTICATED INSTRUMENT.
>> I'M GOING TO DO ONE MORE
QUESTION FOR SOCIAL MEDIA AND GO
BACK TO THE PHONE LINE.
THE QUESTION IS, WE DIDN'T TALK
MORE ABOUT AAG.
AND HE HAS TELL US MORE ABOUT IT
AND WHAT KIND OF PLANET IS IT?
>> THIS IS ANDREW, SO I TALKED
ABOUT KEPLER ADG A FEW MINUTES
AGO, BUT I'LL SAY MORE.
IT'S ABOUT THE SIZE OF EARTH.
IT'S IN A 14-SIX-DAY ORBITAL
PERIOD, I BELIEVE.
AND IT'S IN A FIXED PLANET
SYSTEM.
FIVE OF WHICH ARE IN A CHAIN
WHICH I DESCRIBED.
BUT AS FAR AS IT'S COOLER --
IT'S STAR IS COOLER THAN THE
SUN, IT'S PROBABLY A DWARF.
AND ALL OF THE PLANETS IN THIS
SYSTEM ORBIT VERY VERY TIGHTLY
PACKED IN.
THEY HAVE ORBITAL PERIODS OF
LESS THAN 14 DAYS, AND ONE OF
THEM IS EXTREMELY SHORT.
IT'S ABOUT 28 DAYS I BELIEVE.
>> THANK YOU.
NEXT, WE HAVE DAN FROM SCIENCE
MAGAZINE ON THE PHONE.
>> HI, AND THANKS FOR THIS.
I JUST WANT TO ASK, IN THE
KEPLER 90 SYSTEM, YOU HAVE THESE
WELL ORDERED ORBITS IN A NICE
PROGRESSION OF SIZES, IS THERE
ANY EVIDENCE AS TO WHETHER THEY
FORMED IN THOSE POSITIONS FROM A
PARTICULARLY MASSIVE DISC, OR
THEY MIGRATED FROM FURTHER OUT
AND INTO THAT POSITION?
>> THIS IS ANDREW, AND I COULD

TALK A LITTLE BIT ABOUT THAT.
SO FIRST OF ALL, I WOULD LIKE TO
SAY THAT WE DON'T ENTIRELY
UNDERSTAND THE PROCESS OF PLANET
FORMATION AND THE PROCESS OF
PLANET MIGRATION.
BACK BEFORE WE DETECTED
EXOPLANETS, WE SAW ONE EXAMPLE,
WHICH WAS OUR SOLAR SYSTEM, AND
WE CAME UP WITH THEORIES THAT
DESCRIBES THE SOLAR SYSTEM'S
FORMATION EXTREMELY WELL.
WE CAN PREDICT WHERE THE PLANETS
WILL FORM, AND WHAT THEIR MASSES
WILL BE ROUGHLY, AND EVERYTHING
SEEMS TO WORK GREAT.
AND HE HAS THEM WE START TO
IDENTIFY THE EXOSYSTEMS WHICH
TURNED ALL OF THIS ON THEIR
HEADS.
WE FOUND GIANT PLANETS, AND WE
DON'T UNDERSTAND HOW THEY FORM
AND COME TO BE WHERE THEY ARE,
AND WE IN GENERAL DON'T BELIEVE
THAT WE HAVE A COMPREHENSIVE
UNDERSTANDING OF HOW PLANETS
FORM AND COME TO BE IN THEIR
CURRENT ORBITS.
ALL OF THAT BEING SAID, IF WE GO
BACK TO THE THEORIES THAT WE
CAME UP WITH BASED ON OUR OWN
SOLAR SYSTEM, WE CAN MAKE SOME
SPECULATION ABOUT THE KEPLER 90
SYSTEM.
I MENTIONED EARLIER THAT THE
KEPLER 90 SEEMED TO HAVE THIS
ORDER WHERE THE BIG PLANETS
WERER FURTHER OUT AND THE SOLAR
SYSTEM, PLANETS LIKE JUPITER AND
HATERN FORMED BEYOND THE
SNOWLINE, WHERE ICE FORMED AND
HELPED THE PLANETS COME
TOGETHER.
BUT THE KEPLER 90 PLANETS ARE

BEYOND THE SNOWLINE.
IF YOU BELIEVE THEY FORMED THIS
WAY, THERE MUST HAVE BEEN WAYS
FOR THEM TO MIGRATE TO THEIR
CURRENT PLANETARY DISC.
BUT IN THE BEGINNINGS, I DON'T
THINK THAT WE KNOW ENOUGH ABOUT
HOW THE PLANETS FORM, ESPECIALLY
GIVEN THE HUGE DUMP OF
INFORMATION THAT KEPLER HAS
GIVEN US IN THE LAST NINE YEARS,
SAYING FOR SURE HOW THE
EXOPLANETS IN GENERAL FORM AND
MIGRATE.
>> OKAY, THANKS.
>> NEXT, WE HAVE MONICA YOUNG
FROM SCIENCE TELESCOPE.
>> THANKS FOR TALKING WITH US,
AND I WAS CURIOUS ABOUT WHAT YOU
SAID EARLIER ABOUT THE
SUPERVISED LEARNING AND YOU SAID
THAT YOU OFFERED A TRAINING
EXAMPLE AND I WAS CURIOUS IF YOU
HAVE PLANS TO MAKE IT
UNSUPERVISED LEARNING, EXAMPLES
WHICH TAKE A LOT OF HUMAN INPUT
AND SERVE DATA SETS THAT MIGHT
NOT BE POSSIBLE.
WHAT YOUR PLANS WERE FOR THAT.
>> THIS IS CHRIS, AND THANKS
FOR YOUR QUESTION.
YES, WHAT YOU SAID, YES, SO
THIS, IN THIS PROJECT, WE USE A
TYPE OF MACHINE LEARNING CALLED
SUPERVISED MACHINE LEARNING,
WHICH MEANS THAT WE RELY ON A
LARGE SET OF DATA THAT HAS
ALREADY BEEN LABELED.
IN OTHER WORDS, WE ALREADY HAVE
THE RIGHT ANSWERS, AND WE TOLD
OUR MODEL WHAT THE CORRECT
ANSWERS WERE, THAT THERE'S
ANOTHER APPROACH TO MACHINE
LEARNING CALLED UNSUPERVISED

LEARNING, WHERE YOU DON'T HAVE
THE RIGHT ANSWERS, ALL YOU HAVE
IS A LARGE AMOUNT OF DATA.
AND YOU TURN A MODEL TO THAT
DATA, AND ASK IT TO LEARN
THINGS, EVEN THOUGH YOU HAVEN'T
SPECIFICALLY TOLD IT WHAT THE
RIGHT ANSWERS ARE.
THIS IS AN EXCITING TYPE OF
MACHINE LEARNING AS WELL, AND
IT'S GREAT WHEN YOU DON'T
ACTUALLY HAVE A LARGE LABELED
TRAINING SET.
AND HE HAS IT'S ACTUALLY VERY
ACTIVE AREA OF MACHINE LEARNING
RESEARCH.
I WOULD SAY THAT MOST OF THE
LARGE SUCCESSFUL APPLICATIONS IN
MACHINE LEARNING THAT YOU'LL SEE
ACTUALLY HAVE COME ABOUT WITH
SUPERVISED MACHINE LEARNING.
AND UNSUPERVISED MACHINE
LEARNING IS SORT OF NOT
NECESSARILY AS CLEAR CUT ON HOW
TO APPLY IT TO A PROBLEM, SO I
THINK IT WOULD BE EXCITING TO
EXPLORE UNSUPERVISED TECHNIQUES
ON THIS, BUT WE DON'T HAVE ANY
PLANS AT THIS TIME.
>> IF I WOULD ASK A QUICK
FOLLOWUP TOO, YOU MENTIONED THAT
YOU HAVE 96% ACCURACY FOR THE
PLANET DETECTION AND CAN YOU
EXPLAIN THE FALSE POSITIVES OR
NEGATIVES?
WHAT YOU WERE MEASURING?
>> SO IN THIS CASE, THE 96%
ACCURACY, WE HELD OUT A SMALL
NUMBER OF -- IT WAS ACTUALLY 10%
OF THE EXAMPLES THAT HAD ALREADY
BEEN LABELED BY THE SCIENTISTS,
AND WE DIDN'T SHOW IT TO OUR
MODEL DURING TRAINING AND ONCE
IT WAS FINISHED TRAIN, WE RAN

OUR MODEL OVER THAT 10% OF
SIGNALS THAT HAVE IT HAD NEVER
SEEN BEFORE TO SEE HOW IT DID,
AND THE ACCURACY NUMBER IN THIS
CASE IS SIMPLY THE NUMBER OF
CORRECT CLASSIFICATIONS WHERE
THE CLASSIFICATION HERE IS THE
CLASSIFICATION, IS THIS A PLANET
OR NOT A PLANET, DIVIDED BY THE
TOTAL NUMBER OF THINGS THAT IT
PREDICTED.
>> GREAT, THANK YOU.
>> NEXT, WE HAVE IRENE FROM
AVIATION WEEK.
>> HI, I HAVE TWO QUICK
QUESTIONS.
FIRST, ARE Y'ALL PLANNING ON
PUBLISHING A PAPER ABOUT THIS?
AND THE SECOND QUESTION, I THINK
I HEARD THE ANSWER TO THIS, BUT
JUSTIFY TO CLARIFY THE
DIFFERENCE BETWEEN THE TECHNIQUE
YOU USED TO FIND THE EXOPLANETS
THIS TIME, ASIDE FROM HITTING
PAY DIRT IS THAT THE SOFTWARE
WAS MODIFIED TO SCAN FOR WEAK
SIGNALS, AND NOT STRONG ONES,
AND IS THERE ANY OTHER
DIFFERENCE BETWEEN WHAT CHANGED,
AND PREVIOUS EFFORTS TO USE
NEURAL NETWORKS TO LOOK FOR
EXOPLANETS?
THANKS.
>> I CAN TAKE A STAB AT THAT.
SO THIS IS ANDREW.
YES, WE HAVE PUBLISHED A PAPER,
IT'S NOT PUBLISHED YET, BUT IT'S
ACCEPTED FOR PUP MIX, AND IT
WILL BE POSTED ON THE ARCHIVES
TONIGHT.
AND HE HAS A COPY OF THE PAPER
IS AVAILABLE FOR DOWNLOAD NOW.
I BELIEVE IT'S IN THE PRESS
RELEASE.

BUT MAYBE SOMEONE CAN CONFIRM
THAT FOR ME.
>> YES, IT CURRENTLY CAN BE
FOUND IN THE PRESS RELEASE.
>> YEP.
AND THE SECOND QUESTION WAS
ASKING ABOUT WHAT THE
DIFFERENCES WERE BETWEEN OUR
SEARCH FOR PLANETS AND DATA
USING NEURAL NETWORKS AND OTHER
PREVIOUS SEARCHES FOR DATA USING
NETWORKS, IS THAT RIGHT?
>> YES.
>> ONE OF THE THINGS THAT'S
INTERESTING IS THERE HAVE NOT
BEEN VERY MANY SEARCHES FOR
PLANETS IN KEPLER DATA USING
NEURAL NETWORKS, THERE HAVE BEEN
TWO OR THREE PAPERS REFINE THAT
HAD USED NEURAL NETWORKS TO
IDENTIFY PLANETS AND SIMULATED
KEPLER DATA, WHICH HAVE SHOWN
THAT NEURAL NETWORKS CAN
IDENTIFY PREVIOUSLY KNOWN
PLANETS IN KEPLER DATE A. BUT AS
FAR AS WE'RE AWARE, NO ONE HAS
IT CONDUCTED A SEARCH LIKE THIS
IN KEPLER DATA USING NEURAL
NETWORKS.
DOES ANYONE ELSE HAVE ANYTHING
ELSE TO SAY ABOUT THAT?
>> THIS IS CHRIS.
YEAH, I THINK ANOTHER QUESTION,
WHICH I'LL ADDRESS IS ABOUT YOUR
QUESTION ABOUT THE FACT THAT WE
TURNED DOWN THE THRESHOLD OF THE
SEARCH FOR CANDIDATE SIGNALS,
AND THEREFORE, WE LOOKED AT THE
WEAKER SIGNALS, SO JUST TO
CLARIFY WHAT WE MIXED THERE,
PREVIOUS SEARCHES OF THE KEPLER
DATA, WITH THE STRONGER SIGNALS,
WHICH ARE THE MOST LIKELY TO BE
REAL PLANETS, AND THEN, YOU

KNOW, HUMANS OR OTHER AUTOMATED
SOFTWARE WOULD EXAMINE THOSE TO
DECIDE IF THEY WERE NORPLANTS
REAL PLANETS OR NOT, AND IN OUR
SEARCH, WE RAN A SIMILAR SEARCH
FOR SIGNALS FOR CANDIDATE
SIGNALS, AND YES, WE ACTUALLY
FOCUSED ON THE WEAKER SIGNALS,
AND THEN WHAT WE DID, WE
ACTUALLY APPLIED OUR NEURAL
NETWORK MODEL TO THOSE WEAKER
SIGNALS TO BASICALLY ASK WHICH
OF THESE WEAK SIGNALS, AND
THAT'S THE KEY DIFFERENCE WITH
THIS WORK.
>> CHRIS, AND ARE THERE ANY
OTHER PEOPLE AT GOOGLE.
>> THERE ARE A LARGE NUMBER OF
EFFORTS AT GOOGLE TO USE MACHINE
LEARNING SCIENCE, AND I'M NOT
AWARE OF ANY OTHER GOING TO THE
EFFORTS IN ASTRONOMY
SPECIFICALLY.
BUT I AM AWARE OF OTHER EFFORTS
TO USE NEURAL NETWORKS, FOR
EXAMPLE TO PREDICT THE
PROPERTIES OF MOLECULES, AND TO
DETECT DIABETIC EYE DISEASE, BUT
I'M NOT SPECIFICALLY AWARE OF
ANY OTHER ASTRONOMY PROJECTS AT
GOOGLE.
BUT IT'S A LARGE PLAY, SO THERE
VERY WELL BE SOME.
>> THANK YOU, NEXT, WE HAVE
CAESAR FROM GLOBAL NEWSPAPER
BRAZIL.
>> HELLO, AND THANK YOU FOR
TAKING MY QUESTION.
I WOULD LIKE TO KNOW, IS THIS
KIND OF MACHINE LEARNING, COULD
BE USED ON TEST DATA FOR THE
SEARCH FOR EARTH-LIKE PLANETS?
AND HOW -- ON THE STAR, AND ON
THE.

>> THIS IS CHRIS, AND I MIGHT
TAKE A STAB AT THE FIRST PART OF
THE QUESTION, WHERE YOU ASKED IF
THIS TYPE OF MACHINE LEARNING
WOULD BE APPLIED TO THE TEST
MISSION.
>> YEAH.
>> SO ONE THING THAT YOU RECALL
ABOUT THIS WORK, THE KEY
INGREDIENT WOULD BE THE 16,000
SIGNALS EXAMINED AND LABELED BY
SCIENTISTS.
WE WON'T ACTUALLY HAVE A SET OF
PREVIOUSLY KNOWN AND IDENTIFIED
SIGNALS.
SO THERE ARE TWO WAYS IN WHICH
WE WILL BE ABLE TO APPLY THIS
SAME SORT OF TECHNIQUE TO THE
TEST MISSION.
ONE APPROACH IS PERHAPS WE COULD
JUST WAIT A LITTLE WHILE UNTIL
SOME HUMANS LABEL ENOUGH TEST
SIGNALS IN ORDER FOR US TO TRAIN
A MACHINE LEARNING MODEL BASED
ON THE HUMAN CLASSIFICATIONS,
BUT ANOTHER PERHAPS MORE, AND
SIMULATE SIGNALS FROM THE TEST
MISSION, AND THEN USE THOSE
SIMULATED SIGNALS TO TRAIN THE
MACHINE LEARNING MODEL.
AND HE HAS THEN APPLY IT TO THE
REAL SIGNALS.
THAT'S A LITTLE BIT MORE
EXPLORATORY.
AND IT MAY BE MORE DIFFICULT TO
GET THAT TO WORK.
>> SO THIS IS ANDREW.
THE SECOND HALF OF YOUR
QUESTION, ORBITS AROUND STARS,
IS THAT RIGHT?
>> YES, I THINK THAT'S
PLAUSIBLE.
ONE OF THE REASONS THAT THESE
EARTH-LIKE PLANETS AROUND

SUP-LIKE STARS AND THESE LONG
ORBITS ARE RARE, THEY'RE HARD TO
FIND.
THEY'RE RIGHT ON THE EDGE OF
WHAT KEPLER CAN ACTUALLY DETECT.
AND HE HAS SO WE'RE HOPING THAT
IF WE USE THIS KIND OF STRATEGY
OF LOOKING THROUGH THE WEAKER
SIGNALS, AND USING MACHINE
LEARNING TO SEPARATE OUT THE
FALSE POSITIVES FROM THE REAL
PLANETS, WE CAN BOOST KEPLER'S
SYSTEM TO BE JUST A LITTLE BIT
MORE, AND HOPEFULLY BE ABLE TO
FIND THESE EXTREMELY INTERESTING
AND IT EXCITING PLANETS.
>> OKAY, THANK YOU.
>> WITH THAT, WE HAVE TIME FOR
THREE MORE QUESTIONS, AND WE ARE
GOING TO TAKE QUESTIONS FROM
POPULAR SCIENCE MAGAZINE, AND
THEN THE "NEW YORK TIMES."
LET'S GO WITH DAVE FROM BUSINESS
INSIDER.
>> THANK YOU FOR TAKING ALL OF
OUR QUESTIONS.
I'M GOING TO CRAM IN JUST A
COUPLE MORE HERE.
SO IS THERE A CATCHY NAME OR A
SUCH NAME FOR THIS MACHINE
LEARNING MODEL?
IF YOU HAVE A NICKNAME FOR IT,
IT SHOULD BE CALLED THE CATS AND
DOGS MODEL.
THAT'S QUESTION NUMBER ONE, AND
THEN THE OTHER QUESTION, HELP ME
UPWARDS, YOU KNOW THERE'S A LOT
OF OTHER KEPLER DATA THAT
REMAINS, AND HOW MANY MORE
TARGETS ARE YOU GOING TO LOOK
AT?
AND HOW MANY PLANETS DO YOU
EXPECT TO FIND BASED ON WHAT YOU
FOUND IN IN INITIAL RUN?

AND IF I HAVE TIME FOR A THIRD,
I'LL DO THAT.
>> THIS IS CHRIS, AND FOR THE
FIRST PART OF YOUR QUESTION, NO,
WE ACTUALLY DON'T HAVE A CATCHY
NAME.
SO PERHAPS THAT'S UP TO SOMEONE
TO SUGGEST A GOOD ONE FOR US.
IN TERMS OF TARGETS TO LOOK AT,
WE HAVE CONCRETE PLANS IT LOOK
AT THE REMAINDER OF THE DATA SET
FROM THE MAIN KEPLER MISSION,
WHICH IS AT LEAST 150,000.
IN TERMS OF HOW MANY MORE
PLANETS WE EXPECT TO FIND, I
WOULDN'T REALLY WANT TO
SPECULATE THERE, BECAUSE I DON'T
KNOW.
ONE OF THE THINGS WHICH WE DID
IN THIS PROJECTS, WE SEARCHED
FOR NEW PLANETS AROUND STARS
WHICH ARE ALREADY KNOWN TO HOST
PLANETS, AND THEREFORE, WE KNOW
THAT THE STAR ALREADY HOSTS
PLANETS WHERE THE ORBITS ARE
ALIGNED IN A WAY THAT THE KEPLER
TELESCOPE CAN DETECT THEM.
SO WHEN WE TURN OUR MACHINE
LEARNING MODEL TO NEW STARS,
WHICH PROBABLY WILL HAVE PLANETS
AROUND THEM, IT WILL BE THOSE
WHOSE ORBITS ARE NOT INCLINED TO
DETECT THOSE.
SO SURE HOW MANY WE'LL FIND, BUT
I CERTAINLY HOPE TO FIND SOME
MORE, AND PERHAPS ANDREW WILL
HAVE ANYTHING ELSE.
>>> YEAH, IT'S HARD TO GUESS HOW
MANY NEW PLANETS WE'LL FIND,
PARTIALLY, BECAUSE IF WE FIND
THEM, THEY WILL BE AT A NEW
REGIME.
THE SMALLEST PLANETS AND THE
LONGEST PERIOD PLANETS, AND 23

YOU GO TO A NEW REGIME, IT'S
HARD TO PREDICT BECAUSE YOU'VE
NEVER LOOKED BEFORE.
AND THAT'S WHY WE'RE DOING IT,
WE WANT TO FIND OUT.
>> OKAY, LET'S GO TO ROBERT FROM
POPULAR SCIENCE MAGAZINE.
>> HELLO, EVERYONE, AND I'LL
MAKE IT QUICK AND EASY FUR.
I THINK THAT I ALREADY KNOW THE
ANSWER TO THIS, BUT IS THIS THE
FIRST TIME TO YOUR KNOWLEDGE
THAT AN ARTIFICIAL INTELLIGENCE
SYSTEM NETWORK HAS DISCOVERED
EXOPLANETS?
>> THIS IS JESSE.
I'LL START WITH THIS, AND THEN
CHRIS AND ANDREW CAN CORRECT ME
IF I'M INCORRECT.
SO MACHINE LEARNING AND
ARTIFICIAL INTELLIGENCE IS A
PRETTY DARNED BROAD CATEGORY,
AND CERTAINLY VERSIONS OF
MACHINE LEARNING HAVE BEEN USED.
BUT THIS IS THE FIRST TIME THAT
AS FAR AS WE HAVE BEEN ABLE TO
FIGURE OUT THAT A NEURAL NETWORK
HAS BEEN USED TO SUCCESSFULLY
IDENTIFY A PLANET.
AND HE HAS NEURAL NETWORKS ARE
POWERFUL ALGORITHMS, AND IT'S
EXCITING TO SEE IT APPLIED TO
THIS DATA SET.
>> YES, THIS IS CHRIS, I
BELIEVE, I ALSO BELIEVE AS JESSE
SAID THAT THIS IS THE FIRST TIME
THAT A NEURAL NETWORK
SPECIFICALLY HAS BEEN USED TO
IDENTIFY A NEW EXOPLANET.
AND THE OTHER SORT OF FIRST
ABOUT THIS, I BELIEVE THAT WE'RE
THE FIRST TO ACTUAL TAKE A
NEURAL NETWORK AND USE IT TO
EXPLORE THIS NEW REGIME OF DATA,

THESE WEAKER SIGNALS, AND THIS
PRESENTS A REALLY GREAT
OPPORTUNITY.
BECAUSE THERE'S GOING TO BE LOTS
MORE WEAKER SIGNALS FOR US TO
LOOK AT WHEN WE TURN TO THE FULL
KEPLER DATA SET.
>> THIS IS ANDREW, AND YEAH, I
AGREE WITH PRETTY MUCH
EVERYTHING THAT HAS BEEN SAID.
I DO WANT TO CALL OUT THE
DISCOVERY OF LHS1140B.
WHICH WAS DISCOVERED BY JASON
DETMAN, USING THE TELL COPE.
AND HE WAS ASSISTED BY A NEURAL
NETWORK, WHICH IDENTIFIED WHICH
TRANSITS DETECTED FROM THE
GROUND MAY OR MAY NOT HAVE BEEN
DETECTED BY BAD WEATHER, AND
THEY WERE FALSE POSITIVES.
SO IT WAS A COMPLIMENTARY
APPROACH TO HELP DISCOVER
PLANETS, BUT IT'S FUNDAMENTALLY
DIFFERENT THAN WHAT WE'RE DOING
HERE.
>> THANKS SO MUCH.
>> OKAY, LAST QUESTION.
WE HAVE NICHOLAS FROM THE
"NEW YORK TIMES."
>> THANK YOU SO MUCH.
THE LAST QUESTION, JUST SPARKED
A QUICK QUESTION IN MY HEAD.
SO I HAVE TWO HERE.
CAN YOU GIVE US ONE MORE TIME, A
SIMPLE LAYMAN'S DEFINITION OF
WHAT YOU MEAN WHEN YOU SAY
NEURAL NETWORK, AND KEPLER 90,
EIGHT PLANETS ARE SCRUNCHED
TOGETHER.
AND HE HAS HOW THIS IS MUCH
DIFFERENT THAN OUR SOLAR SYSTEM,
IS IT SOFTEN THAT THE PLANETS IN
THAT SOLAR SYSTEM ARE SCRUNCHED
TOGETHER?

OR IS IT THAT OUR TECHNOLOGY CAN
ONLY SEE THE PLANETS THAT ARE
REALLY CLOSE TO THEIR SUB MATTER
SCRUNCHED TOGETHER, SO IT MIGHT
NOT BE THAT OUT OF THE ORDINARY?
THANK YOU.
>> THIS IS CHRIS, SO I'LL TAKE
THE FIRST PART OF THAT QUESTION.
AND I'LL TRY TO DESCRIBE THAT.
AND NEURAL NETWORKING IN AS FEW
SENTENCES AS POSSIBLE.
A NEURAL NETWORK IS A MACHINE
LEARNING ALGORITHM THAT IS VERY
LOOSELY INSPIRED BY THE HUMAN
BRAIN.
IT HAS A VARIETY OF USES, BUT
LET'S FOCUS ON THE FACT THAT IT
CAN BE USED TO CLASSIFY INPUTS.
SO IN THIS CASE, SO WE ALREADY
TALKED ABOUT THE QUESTION OF
CLASSIFYING MINIMALS OF CATS AND
DOGS, OR IMAGES OF TRUCKS AND
CARS, OR ANYTHING LIKE THAT.
OR IN THIS CASE, CLASSIFYING
SIGNALS FROM THE KEPLER
TELESCOPE AS BEING PLANETS OR
NOT PLANETS.
SO IT'S A TYPE OF ALGORITHM THAT
CAN ACTUALLY CLASSIFY INPUTS,
AND HOW IT DOES THAT, IT
ACTUALLY LEARNS BY EXAMPLE.
SO WE'RE ACTUALLY GOING TO TRAIN
THIS MODEL BY GIVING IT A LARGE
SET OF EXAMPLES IN LAWING THE
NEURAL NETWORK TO ACTUALLY LEARN
WHICH PATTERNS IN THE INPUT WILL
IT USE TO MAKE THE DECISION TO
CLASSIFY THE INPUT AS ONE
CATEGORY OR ANOTHER.
>> THIS IS ANDREW.
I'LL JUMP IN FOR THE SECOND PART
OF THAT QUESTION, WHICH WAS
ABOUT WHETHER KEPLER 90 IS
REALLY THAT UNUSUAL.

OR IS THIS JUST WHAT WE'RE ABLE
TO SEE.
I THINK THAT'S A REALLY GREAT
QUESTION.
WHEN I THINK ABOUT WHAT WE KNOW,
IT'S VERY LITTLE.
WE HAVE REALLY COMPLETE
UNDERSTANDING OF JUST ONE
PLANETARY SYSTEM, AND THAT'S OUR
OWN SOLAR SYSTEM.
AND HE HAS WHEN WE START ASKING
QUESTIONS, LIKE WHAT ARE THE --
HOW DOES THE SOLAR SYSTEM STACK
UP TO OTHER PLANETARY SYSTEMS?
WE HAVE TO REMEMBER THAT WE HAVE
AN INCOMPLETE VIEW.
SO WE SEARCH FOR SYSTEMS WITH
TRANSITS A LOT.
AND TRANSITS ARE REALLY JUST
SYSTEMS WITH PLANETS, AND WE CAN
SEARCH FOR PLANETS BY
GRAVITATIONAL MICROSENTENCING,
AND THIS ASSESSES THEM FURTHER
AWAY FROM THEIR STARS.
EXTREME, WE'LL BE BE ABLE TO
SEARCH FOR PLANETS USING DIRECT
IMAGING, BY SEPARATING THE
LIGHTS OF THE PLANET FROM THE
LIGHTS OF THEIR STARS.
AND ALL OF THESE TECHNIQUES WILL
GIVE US DIFFERENT VIEWS OF
PLANETARY SYSTEMS, AND ONLY WHEN
WE COMBINE THEM TOGETHER CAN WE
GET FULL VIEWS OF EXOPLANETS AND
PUT OUR OWN SOLAR SYSTEM INTO
CONTEXT, AND ASK HOW COMMON ARE
EIGHT PLANET SYSTEMS, LIKE OUR
OWN WITH ORBIT SPACES THIS FAR
APART COMPARED TO THE HIGHLY
PACKED SYSTEMS LIKE KEPLER 90,
OR THE SYSTEMS AROUND HR8799.
>> SO WE JUST DO NOT KNOW YET.
>> YEAH, I WOULD SAY THAT IT'S
TOO EARLY TO SAY, AND THAT'S ONE

OF THE MOST EXCITING THINGS THAT WILL COME OUT IN THE NEXT FEW DECADES, WE'LL GET THE TECHNOLOGIES AND THE MISSIONS TO START LOOKING FOR PLANETS IN THESE ADDITIONAL WAYS.

>> GREAT, THANK YOU.

>> AND THAT'S WHAT WE HAVE FOR TODAY'S TELECON.

I WOULD LIKE TO THANK THE PAN LIFTS AND THE OPERATOR FOR THEIR TIME.

AND HE HAS ASK THE PANELISTS TO STAY ON FOR A FEW MINUTES FOR A FOLLOWUP.

CAN YOU LISTEN TO IT AGAIN WITH THE INFORMATION THAT'S ON OUR PRESS BRIEFING SITE.

TO FIND OUT MORE ABOUT THE FINDINGS OR ANY OF THE NASA PROJECTS, VISIT US AT THE WEB AT WWW.NASA.GOV OR MANY OF THE MEDIA VENUES, SUCH AS FACEBOOK, GOOGLE, TWITTER AND YOUTUBE.

AGAIN, AMA, AND ME ANYTHING.

SO GO TO SCIENCE FOR MORE, THANKS FOR JOINING US AND HAVE A GREAT DAY.

>> THANK YOU FOR YOUR ATTENDANCE.