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A Bibliometric Perspective Survey of Astronomical Object Tracking System

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Abstract

Advancement in the techniques in the field of Astronomical Object Tracking has been evolved over the years for more accurate results in prediction. Upgradation in Kepler's algorithm aids in the detection of periodic transits of small planets. The tracking of the celestial bodies by NASA shows the trend followed over the years It has been noted that Machine Learning algorithms and the help of Artificial Intelligence have opted for several techniques allied with motion and positioning of the Celestial bodies and yields more accuracy and robustness. The paper discusses the survey and bibliometric analysis of Astronomical Object Tracking from the Scopus database in analyzing the research by area, influential authors, institutions, countries, and funding agency. The 93 research documents are extracted from the research started in this research area till 6th February 2021 from the database. Bibliometric analysis is the statistical analysis of the research published as articles, conference papers, and reviews, which helps in understanding the impact of publication in the research domain globally. The visualization analysis is done with open-source tools namely GPS Visualizer, Gephi, VOS viewer, and

ScienceScape. The visualization aids in a quick and clear understanding of the different perspective as mentioned above in a particular research domain search.

Keywords: Orbital Mechanics, deep learning, Astrophysics and IOT, planet detection and IOT, astronomy tracking and Arduino, solar tracking, Kepler's algorithm, true north detection, celestial mechanics, trajectory prediction

1. Introduction

Astronomical Object tracking includes locating the position of any given Celestial body in the Solar System and predicts its motion and trajectories with laser point accuracy Using the osculating elements and Keplerian algorithm. Kepler's algorithm consists of three laws. The first law states that the planets revolve around in an elliptical motion around the sun as its foci and the center of gravity. The second law states that the radius vector of each planet absolves the same area at the same time. Third, the ratio of the square of each planet's time required to complete one revolution to the cube of the diameter of its orbit is constant for all the planets.

With the advancements in astrophysics, Astronomical tracking includes two major methods, first is implementing Kepler's algorithm using machine learning algorithms to predict the trajectories of the planet. It has been experimentally proven that Machine learning will yield more accurate results than a human eye. Machine learning is the self-learning algorithm that is capable of yielding accurate results and improvise the model into the self-governing model. The second is interfacing the Kepler's equation with the hardware, for which we can use the method of CORDIC double iterations. For an astronomical tracker, it's important to set the motion parameters for understanding the movement processing. Automatic north detection yields the reading of yaw stabilization angle. It helps in calibrating the model in the north direction automatically using a magnetometer. In the respective survey, we examined 35 research paper in respect to the above topics this survey has been carried out so that we can venture out and learn about the domains included in Astronomical trackers.

In the Solar system, all the planets move in an elliptical motion with the sun as the center of gravity present at the foci. In 1609, Kepler stated about the motion shape and mathematics relationship of celestial bodies which are expressed as laws of Kepler's [12]. Kepler's equation helps us to locate the planets on the orbital path as a function of time [1]. In 2014, Kepler's algorithm was improved by using an implicit function. The bounds of this equation are enhanced in such a way that they are more efficient and include less iteration and we do not need to include all the calculations related to quadratic and linear equations with whole range eccentric anomaly and mean anomaly [2]. In 2015, by extracting a cubic equation from the Pade equation improvised Kepler's law for orbital calculations. This gave them time to a point in any bounded Orbit not only to the Inverse Square Law. The equation was enhanced to extract the position as a function of time in the orbital system. Here the antisymmetric nature of Kepler's algorithm is preserved by extracting the cubic equation which provides the Kepler's algorithm. Further simplification of the cubic equation is implemented to obtain eccentric anomaly as a function of Kepler's equation. Finally, we get an expression for the position at the true anomaly as a function of time [3].

In 2020, the CORDIC Double Iteration method was introduced to solve Kepler's equations. The double CORDIC iterations are self-correcting and compensate for the wrong rotation in the successive iteration. This method will overcome the drawback of modifying the whole equation to balance the eccentric anomaly and its hyperbolic nature and also the rotations and velocities of the Keplerian model [4]. With the advancement in astrophysics, Kepler's mission was adapted to predict the oscillations of a red giant. Kepler's mission made use of machine learning to comprehend the oscillation parameters of this star. The datasets included a 1,96,581 Kepler end of task long cadence light curve. Large apertures were used that produce steady light curves on longer time scales. With this method, out of 1,97,000 stars, 21,914 stars were detected and their velocity parameters were also predicted [5].

Kepler Science Operation Centre (SOC) at NASA evolved algorithms for multiple-planet search and transit model-fitting both being a portion of the data authentication components of the Kepler science Data dispensation pipeline. The algorithms functioned in a way that for each target star the transit model parameters were fitted to each threshold crossing event which was in turn produced by the transiting planet search. When we look into the architecture of the system, the light curves are set to reduced parameters wherein the transit epoch time, period of the planetary orbit, transit duration, ratio of the planet to star radius, and ratio of semimajor axis/ star radius were fitted to a geometric transit model [6]. There are two algorithms into existence that are used for identifying and tracking unknown objects in orbits about a celestial body without manual analysis. The algorithms are implemented by e OSIRIS-Rex mission to track the particles disintegrated from the near-earth objects. One algorithm uses image processing techniques that autonomously extract observations of objects from images. The other algorithm produces potential linking independently and tracks the objects in a per-frame sequence when it is given the results of the first algorithm sequentially. This method is particularly brought about to enable tracking and detection of very small objects [7]. Modeling the hardware systems that can perform dynamic interactions in space is expensive. Machine learning technique through its algorithms combats this expense simply by roughly estimating the dynamics in an offline mode. It makes use of the Info-SNOC algorithm with the set cover problem (SCP) which gives information on trajectories. The trajectory is then executed using a closed-loop control law with a safety control filter. The system is then tested on a robotic spacecraft simulator [8].

The trajectory forecast method used for quadrotors forms its basis on a bidirectional gated recurrent unit. Data mining techniques such as Markov models, Kalman filtering can be used to find the active location of objects. This system could be used for actively locating the celestial bodies however it does possess shortcomings. One of which is that this method complies well for slow quadrotors and to be able to predict the trajectories of a celestial body its capacity is very low [9]. There are existing trajectory prediction methods that emphasize ballistic trajectory. For its prediction, the ballistic parameters are to be defined. The trajectory function is given in terms of a differential equation and it can be defined for a linear drag model. It defines a frame of reference which is also called the trajectory principal space since it allows the math outlining the trajectory to be broken down into a condensed and well-mannered form. It comes along with a few properties one of which is that it assures positive velocity [10]. Astrophysicists have conceptualized a convolutional long short term memory method to detect weak target trajectories. This method draws out 15 consecutive infrared images by using a 3-Dimensional convolutional kernel to bring out short-term temporal and spatial information thereby merging the convolutional long-term memory network. The attention mechanism segregates the irrelevant information from the relevant trajectory information [11].

The indices of the spline in the Fast Switch Spline (FSS) function are calculated by using the three vectors which enhance and optimize the calculation of prime polynomial. The K-Vector method is used with the Newton Raphson method to do the statistical analysis which yields very low error as predicted from the theory. This algorithm is used for very high performance and Optimization methods in accelerating the orbital calculation of exoplanet elements in the solar system [20]. It includes Kepler's algorithm calculations related to orbital parameters and the trajectory of mass and its heliocentric motion [12]. More properties of the osculating elements and planetary rotations have been observed. While tracking and targeting the astronomical bodies and satellites in the low Earth orbit region, angle-only navigation plays an important role. This approach is only suitable for a flying object that is at a distance range and not sufficient for the observability property for the space region. The solution to this limitation is to determine the integration of the relative dynamics in the cartesian frame or through the gauss variational equations [13].

The Cartesian coordinates are expressed as the function of time. The Osculating elements are known as orbital elements which are the Delaunay variable and the rotational elements are known as Andoyer variable.

Under certain circumstances, these variable equations show the non-osculating property when the elements depend on the velocity. It is very important to add the extra term to keep the elements osculating. In Kinoshita-Souchay's theory, the elements are introduced in the followed frame. This theory can be used to formulate the angular velocity [14]. Celestial bodies are non-stationary and they evolve after course in their shape, size, and structure. The equation to mathematically implement the translational and rotational motion for the triaxial body in osculating elements can be used for dynamic evolution. When the ellipsoid of inertia and rotation differs from each other, it is preferred to use Poisson’s elements [15]

More than 18 exoplanets have been discovered using the mean motion resonance method. The high-order expansion of secular Hamiltonian in the power of eccentric anomalies could easily predict the motion of the extra planets in the solar system. To achieve the expansion of a secured perturbation, we apply averaging by scissors which fail to implement inside the main motion resonance. Perturbation between the motion of a solar planet is known as great inequality. So, one algorithm is made to find out the limit of application of the secured model for the system closeness to the resonances is known as the first-order lie algorithm which is also used to analyze the proximity of various exoplanets in the solar system [16]. ESA and NASA have recently collaborated to work on the solar orbiter mission. This mission would answer few core issues in terms of heliospheres’ study that emphasizes how the sun generates and gearshifts the heliosphere. It is believed that anti-sunward-propagating Alfvén waves dominate the roughness in the solar wind which is in turn generated by photospheres’ motion. However, it is important to analyze to what extent is the details of the beginning of commotion and solar wind could be extrapolated from the detected variations of fast/slow-wind turbulence. Apparatuses for the rise of solar wind turbulence include slow-fast wind shears, the existence of fine-scale assemblies and inclines [17]. Despite the various technological obstacles related to a large orbital mission Neptune and Uranus that form the ice giant planets, it is believed that the electric power generation technology is accurate for large heliocentric distances. Since the mission concerns ice giants, the propulsion engineering involved finds its basis in the conservation of momentum. It also involves computational challenges because of the long propagation times for the EMF signals traveling between the spacecraft and earth [18].

NASA introduced a mid-IR telescope in a nearby planet like Venus to be able to detect the near-earth objects that are about 120m-150m and to avoid the strain of discerning objects closer to the sun. To further enhance the NEO survey a system model was developed that emphasized the elements of Astrophysics such as, NEO orbital motion, dark current detection, zodiacal light, sky brightness as a function of observatory location, and pointing direction, etc. [19]. Absolute magnetic measurements provide instrument calibration and checking of the data quality. Conventional methods involve determining the vertical and the geographic or the "True North" as the reference direction. A method known as the four positions method accomplishes two sets of 4 measurements at two different directions at the vicinity and finding the position of zero by the method of interpolation. This method when combined at each angular position, a discrete sinus curve is produced. This is under the concept of an automatic setup. Increasing the sensitivity leads to better, efficient, and faster results [21]. Ground-based astrometry links set coordinates with the route of the external light as intercepted by the terrestrial spectator. This catalog data encompasses ICRS ("International Celestial Reference System") right ascent and declination [α, δ], and space in α and δ plus the parallax and radial velocity. For light deflection, the Ant system Algorithm (AsA) is tolerable for mass applications, except adjacent to planets. When calculating the position of the deflecting body the light-time should be measured in the apparent direction. Ground-based applications that use observed directions need admittance to the pressure, temperature, and relative humidity, as well as the observing wavelength as requirements [22].

Stars can't be tossed at speeds greater than their binary orbital velocity and can't exceed the escape speed from a star's surface. In a sample of 16 stars, with extreme circular velocities, an individual star was assigned one orbit and was observed with a set of 4–7 dithered exposures. Twelve of the stars have proper motions that are inconsistent with zero, and thus principally radial trajectories. Given the proper aberrations and uncertainties in proper motion and distance, the data allowed for a wider range of origin locations [23]. Observation from the Night sky exploits the calculations of the telescopes or astronomical ones. Real night sky experiment is an operative, realistic, and more accurate approach for evaluation and testing. The "Accuracy Measurement method of a Star Tracker based on direct Astronomic observation" (AMSTA) takes the detailed gesticulation of the Earth as the reference. Moonlight and clouds have a negligible influence on the dimension process. Subsequent transformations among coordinate systems, the installation matrix comparative to the earthly coordinate system can be obtained. This builds a high accuracy star tracker [24]. In space, a collection of "SmallSats" resounding telescopes with ST aptitude could be a very efficient way to speed up the study of Near-Earth Asteroids. This also produces more precise detour paths for close Earth-Asteroid tactics and thus additional steady probabilities of affecting Earth. Optical Navigation finds another application in accurate ground-based astrometry. This approach differentiates from the other approaches discussed as it's is the finest astrometry for bright goals observed near the center of the field are at ∼10 mas with an incorporation time of 100s. This accuracy is impervious to how profligate the asteroid moves in the sky [25]. To measure Night Sky Brightness (NSB), two methods are implemented; the First one is via mathematical calculations and the second by Sky Quality Meter (SQM) which is a photometric sensor. SQM-LU sensor interfaced with Raspberry pi and PySQM program has been used to read the measurements from the sensor and convert them into real values. The final output was given by the program in .dat format and the graphical format both of which were made available on the server and were accessible anywhere to the user connected on the same LAN as that of the server [26].

Integration of the IoT domain with astrophysics has geared up over the past years. Not only the celestial bodies but also for communicating with the man-made satellites, IoT is now being seen as one of the viable solutions. For broadband communications satellites are dependent on the architecture based on hardware which is rigid and doesn't provide any flexibility. However, due to the recent work is done, methods to use Software Defined Networks (SDN) for satellite and CubeSat communications have been developed as SDNs are suitable for providing connectivity of CubeSats with IoT networks [27]. To maintain that angle, azimuth and elevation of the SPV are regulated using the servo mechanism systems. To compute the azimuth and elevation two types of control systems are employed; open-loop servo and closed-loop computation control systems. For solar tracking, Plataforma Solar de Almeria (PSA) algorithm is used. It gives us the direction of the sun concerning the location (of SPV) and time on earth. The location, date, and time of the observer are mainly taken using a GPS tracker. For SPVs with dynamic location, heading measured using a digital compass, attitude measured using earth gravity sensor, and the speed of the mobile SPV is required to calculate the azimuth and elevation in real-time. The sensors; RM G144 for the detection of heading and attitude, GPS are interfaced using Arduino Mega 2560 which in addition to interfacing the sensors executes the algorithm for conversions and calculation of the output parameters. The microcontroller also adjusts the servo mechanism as per the output.[28]

The use of Arduino Uno is seen in the simulation of low budget rotating CCTV systems where the efficiency desired is equivalent to the CCTVs available with inbuilt driving motors for the camera. In this application, a Joystick, DC motor, Servo motors, relay switch, and a non-rotating camera is connected to the Arduino Uno board and a system for moving CCTV has been successfully simulated. Here the use of joystick is on the user's end to command the movement of the camera in different directions and the servo motors were responsible for the movement of the camera itself [29]. Advancing from IoT, the solar tracking systems have widely been improved by the implementation of Machine Learning algorithms. Models such as fuzzy logic, fuzzy inference logic, and neural networks have been used to determine the azimuth and elevation for the solar tracking systems. Though each of the models has its respective advantages/disadvantages and respective output parameters, the optimal model of regulating the solar tracking systems was developed by integrating the fuzzy networks with the neural networks, resulting in an Adaptive Neural Fuzzy Inference System (ANIFS). ANIFS has proved to be faster, more accurate, and optimal than either of the singular models [30]. In the detection of Cosmic Rays using Cosmic Ray Detector (CRD), the data from CRD is read and stored in the C++ based computer program. To make the CRD portable the computer system is replaced by a Raspberry Pi minicomputer which can be powered using a portable battery. This makes the CRD more efficient and also flexible. After acquiring the data using a source code it can be stored, displayed, or fed to another program for analysis of the gamma and cosmic ray spectrums [31].

The morphology of the galaxies is dynamic and to differentiate between galaxies machine learning has advanced a lot as various parameters related to the morphology and intensity of these galaxies are available. The galaxies can be classified using Convolutional Neural Networks (CNN) as these algorithms take the input in the form of images and extract the important features by themselves. The major advantage of these networks is that the accuracy increases as we go on increasing the volume of the input samples [32]. It was experimentally proved that the classification using Machine Learning (ML) is comparatively robust than human-based visual observations. The application of the deep transfer learning technique by classifying the star cluster samples obtained via Hubble Space Telescope-Physics at High Angular resolution in Nearby Galaxies (HST-PHANGS) Survey was implemented. ResNet18 and VGG19-BN architectures were used for the classification of those clusters and for training the models ImageNet dataset was used [33]. To detect these gravitational lenses very few systems were available earlier. However, with the advancement in Artificial Intelligence reliable algorithms were used to detect the space scale lenses. CMU DeepLens is an advanced method that employs Deep residual networks that are derived from CNNs and provide more advantages than CNNs. The CMU DeepLens lensing system uses binary cross-entropy cost function and provides the output with high resolution and color variations which makes it one of the sophisticated lenses finding systems [34]. Having a robust tracking/detecting system with hardware utilization can be achieved by integrating AI with IoT which is termed as Artificial Intelligence of Things (AIoT). A monitoring system with multiple objection detection with an accuracy of 77% was implemented where the image detection was done faster RCNN model, Object Centerpoint Tracking Algorithm (OCTA) was used for tracking and the monitoring system was set up using a central server to which the user's smartphone was connected and the user was notified by a Social Networking Service [35].

2. Preliminary Data

Bibliometric analysis is the statistical analysis of the research published as articles, conference papers, and reviews, which helps in understanding the impact of publication in the research domain globally [36]. This is the first time to perform such a bibliometric analysis on Astronomical Object Tracking. This research paper is formulated by querying to Scopus database. The citation database is with a wide variety of fields domains viz Physics and Astronomy, Earth and Planetary Sciences, Engineering, and mathematics. The data is fetched from the Scopus database on 6th February 2021. As per the analysis, it was observed that the top 10 keywords for the documents related to astrophysics implementation using IoT and AI are orbits, asteroids, gravitation, numerical methods, celestial mechanics, spacecraft, space flight, astronomy, cosmology, and dynamics, among which 'orbits' is the most used keyword with a citation in 13 papers.

Table 1: Top ten keywords

Keywords	Number of publications
Orbits	13
Asteroids	9
Gravitation	8
Numerical Methods	8
Celestial Mechanics	6
Space Flight	6
Spacecraft	6
Astronomy	4
Cosmology	4
Dynamics	4

Table 2: Type of publications

Document Type	Number of publications
Article	53
Book	21
Review	10
Conference Paper	6
Book Chapter	3

Table 2 shows the type of publication in this research area. Out of the 93 documents taken for the analysis, 53 are articles, 21 are taken from books, 10 are literature reviews, 6 are conference papers while the rest 3 are chapters forms books. Most publications are in the English language and the rest are in Chinese and German language as shown in Table 3.

Table 3: Top Languages

LANGUAGE	Number of publications
English	90
Chinese	2
German	1

2.1 Preliminary data analysis

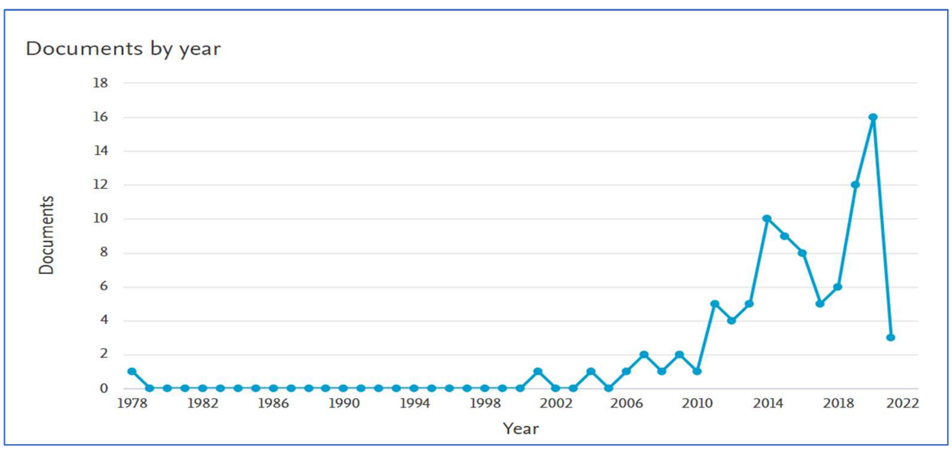

Figure 1: Year wise graph for documents

Figure 1 gives the information about the number of documents published each year that similar to the domain of this paper. There were 16 publications in the year 2020. There are till now 3 publications in 2021.

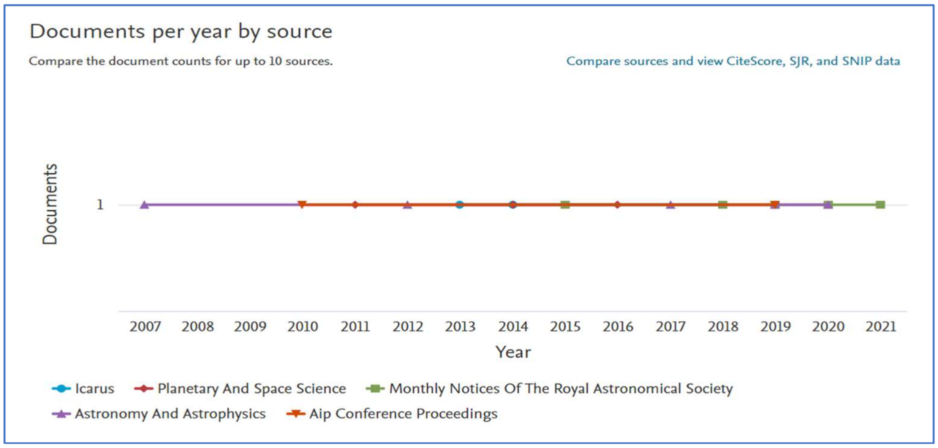

Figure 2: Publishing year for different sources

Figure 2 shows the years in which the papers from each source were published. “Icarus”, “Planetary and Space Science”, “Monthly Notices of the Royal Astronomical Society”, “Astronomy and Astrophysics”, and “Alp Conference Proceedings” are the top five sources publishing in this research domain.

Table 4: Top ten countries

Country	Number of publications
United States	40
Germany	21
France	11
China	9
United Kingdom	9
Belgium	8
Netherlands	8
Spain	8
Italy	7
Japan	6

Table 4 shows the top ten countries with Astronomical Object Tracking. The greatest number of publications have been done in the United States and the top 10 countries for publications include Germany, France, China, United Kingdom, Belgium, Netherlands, Spain, Italy, and Japan.

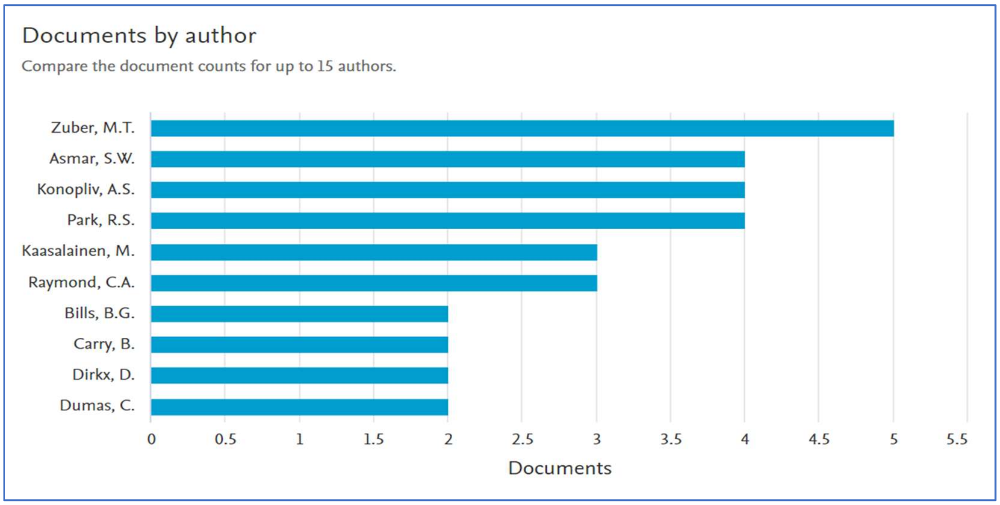

Figure 3: Influential author in Astronomical Object Tracking

Figure 3 shows the top ten influential authors in Astronomical Object Tracking. Zuber M.T has published five papers in this research area. Asmar, S.W., Konopliv, A.S. and Park, R.S. have published four papers each in Astronomical Object Tracking.

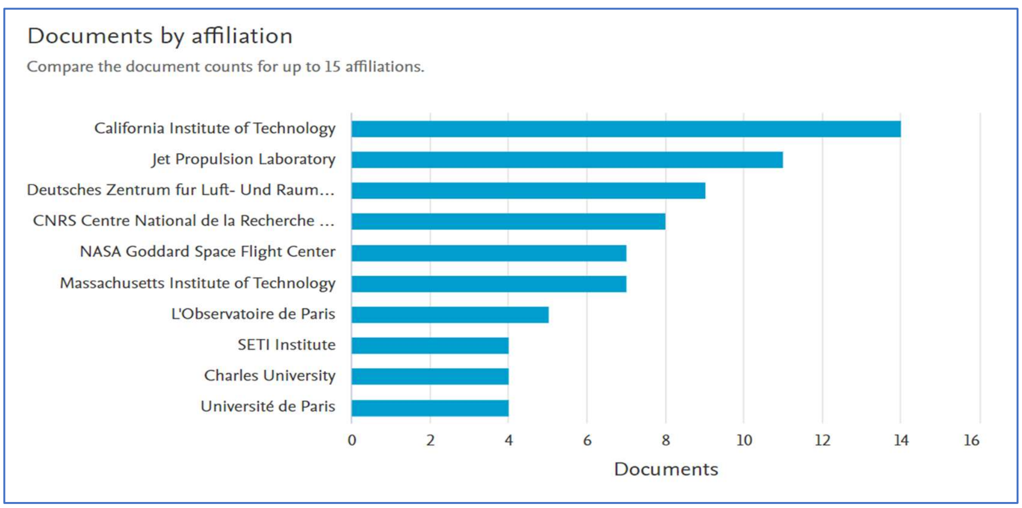

Figure 4: Top ten documents affiliated with different sources

Figure 4 shows the Top ten documents affiliated with different sources. The research is carried out more at the California Institute of Technology, with 14 papers published under them. Jet Propulsion Laboratory is the second topmost affiliation publishing 11 research papers.

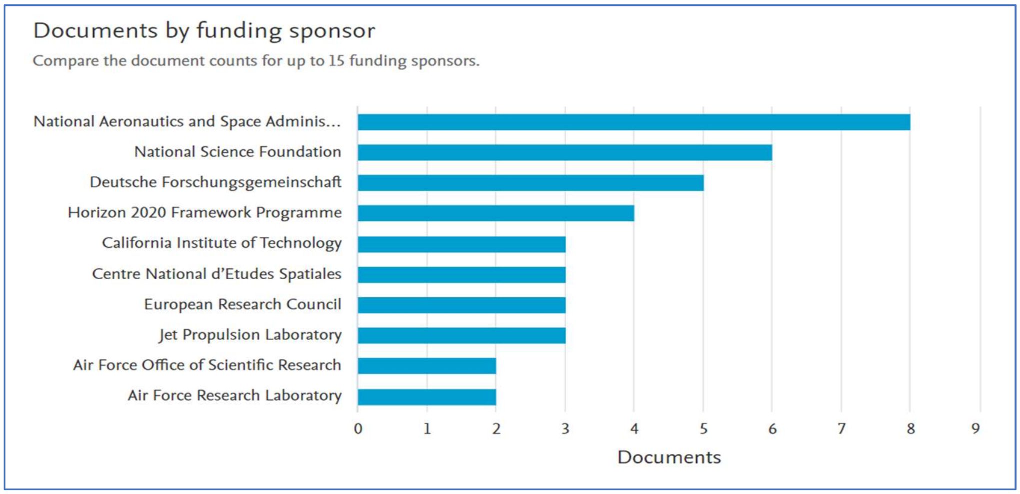

Figure 5: Top ten funding agencies in Astronomical Object Tracking

Figure 5 shows the top ten funding agencies in Astronomical Object Tracking. National Aeronautics and Space Administration is amongst the top funding agencies where eight research documents have come up from them, followed by National Science Foundation with six papers and Deutsche Forschungsgemeinschaft with five publications.

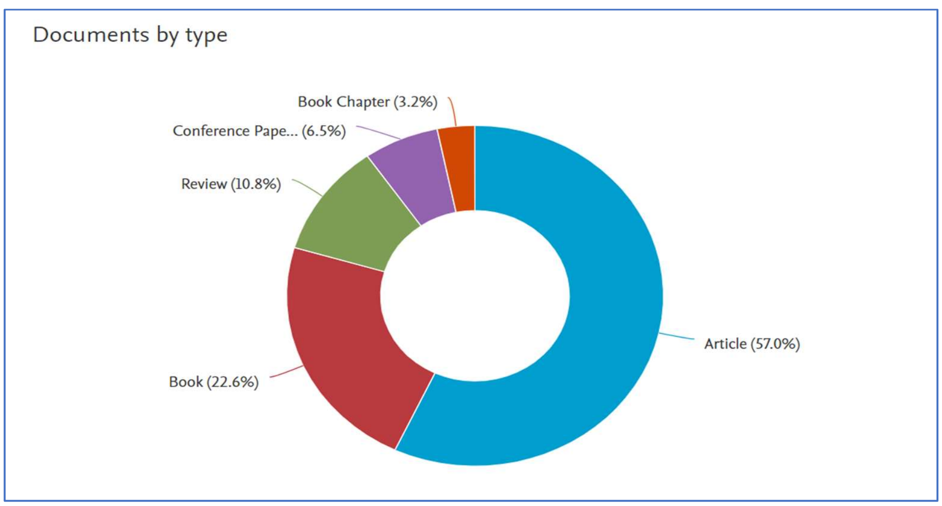

Figure 6: Percentage of documents per each type

Figure 6 shows the percentage of documents that are from books, chapters, conference papers, reviews, and articles. The highest contribution is from research articles with 57.09%, followed by Book with 22.6%, Review with 10.8%, Conference papers with 6.5%, and book chapter with 3.2% of the total publication in Astronomical Object Tracking

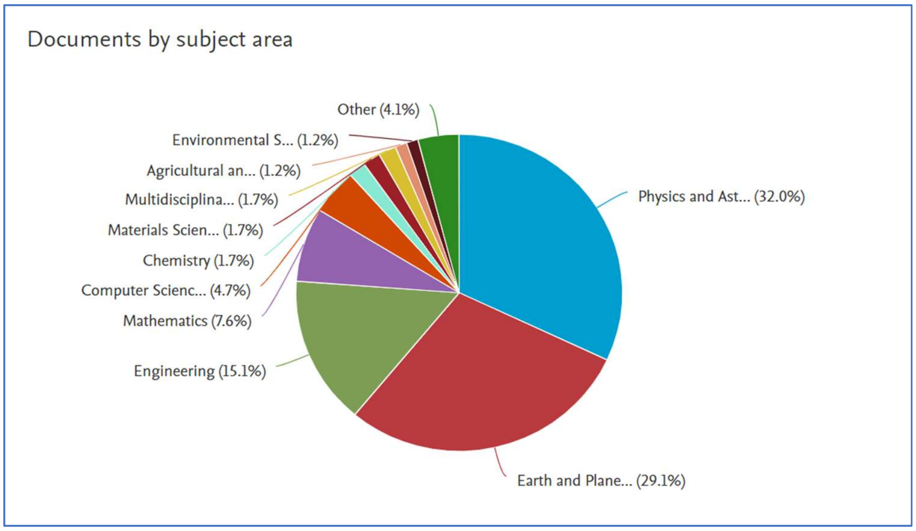

Figure 7: Percentage of documents of each subject area

Figure 7 shows the percentage of the papers related to different domains such as Physics and Astronomy, Earth and Planetary Sciences, Engineering, Mathematics, and computer science, etc.

Bibliometric Analysis:

Bibliometric Analysis refers to the statistical analysis of the documents about various parameters. For this bibliometric analysis, the parameters taken into consideration are year of publishing, affiliations, sources, authors, funding sponsor, document type, source type, domain, and country.

Figure 8: Geographic locations of the study of implementation of astrophysical procedures using IOT and AI

Figure 8 shows the countries located on the map where research is carried out in the field of astrophysical procedures using IoT and AI using GPS visualizer tool. It is seen that many

European countries are involved in this research area. The United States has 40 publications, followed by Germany with 21 publications and France with 11 publications.

The network visualization is done with help of visualizing tools of Gephi, ScienceScape, and VOS viewer. Figure 9 shows a cluster where each group consists of the number of publications of that year. There are maximum publications in the year 2020. The cluster from the year 2011 to 2021 is seen here.

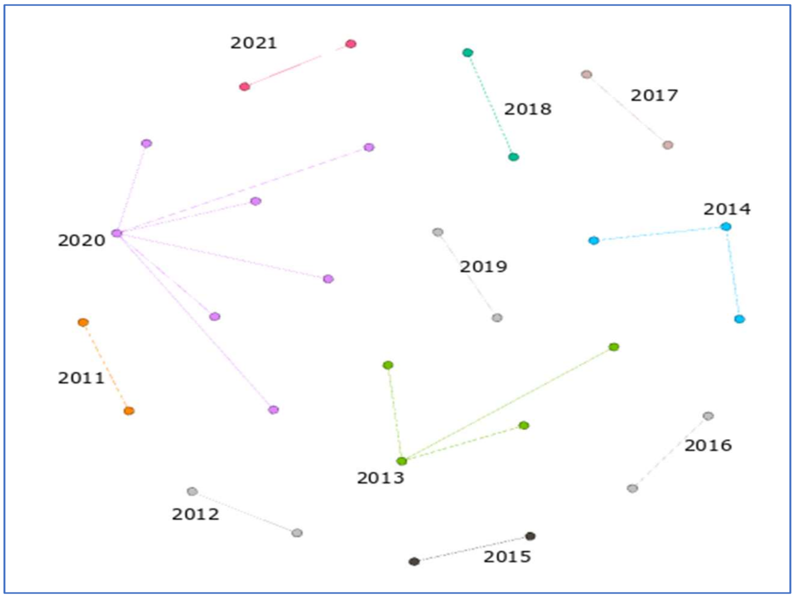

Figure 9: Yearly publication cluster

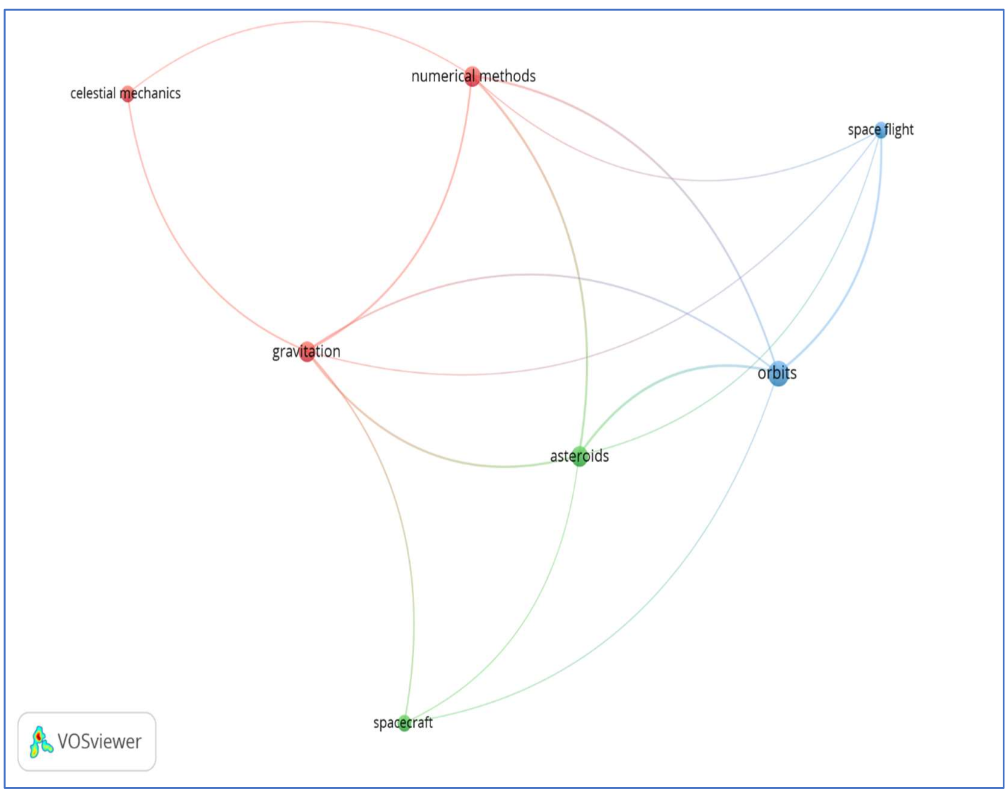

Figure 10: Co-occurrence of the keywords

Figure 10 shows the co-occurrence of each of the topmost keywords concerning another. Orbits, space flight, celestial mechanics, numerical methods, gravitation, asteroids, and spacecraft are the most co-occurring keywords in Astronomical Object Tracking.

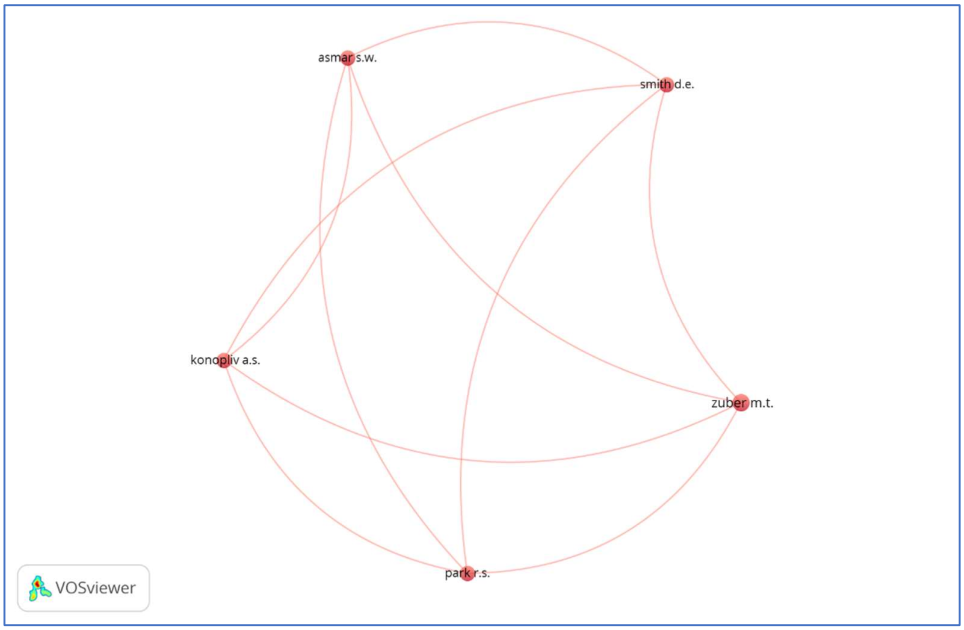

Figure 11: co-authorship of authors

Figure 11 shows the co-authorship of the topmost authors concerning each other. Zuber, M.T., Asmar, S.W., Konopliv, A.S., Park, R.S., and Smith, D.E. are collaboratively researching the field of Astronomical Object Tracking.

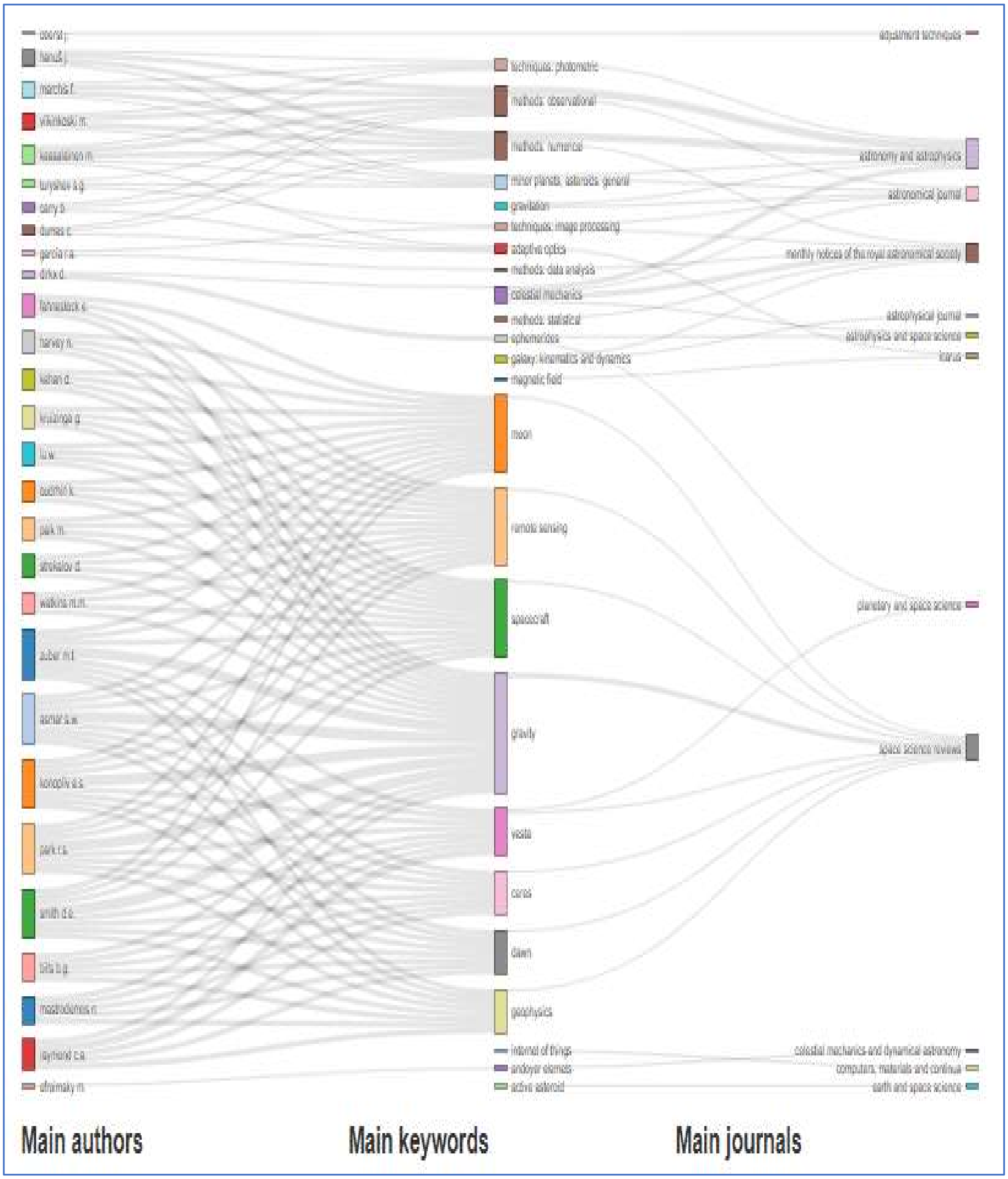

Figure 12: Sankey Graph -Main Authors, main keywords, and main journals

Figure 12 shows the interconnection between main authors, the keywords they used, and the main journal publishing their research work. It is seen that top authors using significant keywords are publishing in Space Science Reviews.

Table 5: Tabular Information of Sankey Graph in Figure. 12

Main authors

- zuber m.t. (5 papers)
- asmar s.w. (4 papers)
- konopliv a.s. (4 papers)
- park r.s. (4 papers)
- smith d.e. (4 papers)
- kaasalainen m. (3 papers)
- raymond c.a. (3 papers)
- bills b.g. (2 papers)
- carry b. (2 papers)
- dirkx d. (2 papers)
- dumas c. (2 papers)
- efroimsky m. (2 papers)
- fahnestock e. (2 papers)
- garcía r.a. (2 papers)
- hanuš j. (2 papers)
- harvey n. (2 papers)
- junkins j.l. (2 papers)
- kahan d. (2 papers)
- kruizinga g. (2 papers)
- lu w. (2 papers)
- marchis f. (2 papers)
- mastrodemos n. (2 papers)
- oberst j. (2 papers)
- oudrhiri k. (2 papers)
- paik m. (2 papers)
- strekalov d. (2 papers)
- taheri e. (2 papers)
- turyshev s.g. (2 papers)
- viikinkoski m. (2 papers)
- watkins m.m. (2 papers)

Main keywords

- celestial mechanics (6 papers)
- gravity (4 papers)
- methods: numerical (4 papers)
- methods: observational (4 papers)
- techniques: image processing (3 papers)
- vesta (3 papers)
- ceres (2 papers)
- dawn (2 papers)
- deep learning (2 papers)
- ephemerides (2 papers)
- galaxy: kinematics and dynamics (2 papers)
- geophysics (2 papers)
- gravitation (2 papers)
- internet of things (2 papers)
- magnetic field (2 papers)
- methods: data analysis (2 papers)
- methods: statistical (2 papers)
- minor planets, asteroids: general (2 papers)
- moon (2 papers)
- remote sensing (2 papers)
- spacecraft (2 papers)
- techniques: photometric (2 papers)
- 67p/churyumov-gerasimenko (1 papers)
- active asteroid (1 papers)
- adaptive neural fuzzy inference system (1 papers)
- adaptive optics (1 papers)
- adjustment techniques (1 papers)
- alfred russel wallace (1 papers)
- algorithm for inverse function (1 papers)
- andoyer elemets (1 papers)

Main journals

- astronomy and astrophysics (5 papers)
- monthly notices of the royal astronomical society (5 papers)
- icarus (4 papers)
- planetary and space science (3 papers)
- aip conference proceedings (2 papers)
- astronomical journal (2 papers)
- celestial mechanics and dynamical astronomy (2 papers)
- classical and quantum gravity (2 papers)
- dlr deutsches zentrum fur luft- und raumfahrt e.v. - forschungsberichte (2 papers)
- international journal of bifurcation and chaos (2 papers)
- space science reviews (2 papers)
- advances in space research (1 papers)
- advances in the astronautical sciences (1 papers)
- american journal of physics (1 papers)
- asteroids: relics of ancient time (1 papers)
- astrobiology (1 papers)
- astronomical applications of astrometry: ten years of exploitation of the hipparcos satellite data (1 papers)
- astrophysical journal (1 papers)
- astrophysics and space science (1 papers)
- atmospheric evolution on inhabited and lifeless worlds (1 papers)
- biological chirality (1 papers)
- celestial mechanics (1 papers)
- chemical reviews (1 papers)
- computers, materials and continua (1 papers)
- dynamics and control of autonomous space vehicles and robotics (1 papers)
- earth and space science (1 papers)
- european space agency, (special publication) esa sp (1 papers)
- extraterrestrial seismology (1 papers)
- fundamentals of spacecraft attitude determination and control (1 papers)
- geochimica et cosmochimica acta (1 papers)

Table 5 shows the tabular information of the Sankey Graph of Figure. 13. The details under each author, keyword, and journal with the papers published can be evaluated.

Table 6: Top journals publishing in last 5 years

2017

- astronomy and astrophysics 1 paper
- planetary and space science 1 paper
- astronomical journal 1 paper
- atmospheric evolution on inhabited and lifeless worlds 1 paper
- international journal of aerospace engineering 1 paper

2018

- monthly notices of the royal astronomical society 1 paper
- icarus 1 paper
- astronomical journal 1 paper
- dlr deutsches zentrum fur luft- und raumfahrt e.v. - forschungsberichte 1 paper
- geoscientific instrumentation, methods and data systems 1 paper
- journal of geodesy 1 paper

2019

- astronomy and astrophysics 1 paper
- monthly notices of the royal astronomical society 1 paper
- classical and quantum gravity 1 paper
- advances in the astronautical sciences 1 paper
- astrophysics and space science 1 paper
- biological chirality 1 paper
- dynamics and control of autonomous space vehicles and robotics 1 paper
- ieee international conference on electro information technology 1 paper
- journal of physics: conference series 1 paper
- news of the national academy of sciences of the republic of kazakhstan, series of geology and technical sciences 1 paper

2020

- astronomy and astrophysics 1 paper
- monthly notices of the royal astronomical society 1 paper
- aip conference proceedings 1 paper
- international journal of bifurcation and chaos 1 paper
- advances in space research 1 paper
- earth and space science 1 paper
- geochimica et cosmochimica acta 1 paper
- guangxue jingmi gongcheng/optics and precision engineering 1 paper
- ieee communications surveys and tutorials 1 paper
- journal of king saud university - engineering sciences 1 paper

2021

- monthly notices of the royal astronomical society 1 paper
- computers, materials and continua 1 paper
- philosophical transactions of the royal society a: mathematical, physical and engineering sciences 1 paper

Table 6 lists all the topmost publishing journals in the last five years including the current year. Astronomy And Astrophysics and Monthly Notices Of The Royal Astronomical Society are top journals almost publishing each year.

The yearly citation of the publications is shown in Table 7 with the publications in the area of plant disease prediction. The total citation for the 93 publications is 2310 for Scopus data. Table

8 shows the list of the topmost ten papers with citations received by them in the Scopus database. The most cited a paper titled “Fundamentals of spacecraft attitude determination and control” published in the year 2014 has been cited 436 times followed by paper titled “Black holes, gravitational waves and fundamental physics: A roadmap” published in the year 2019 has been cited 224 times.

Table 7: Analysis of citations for publications over the years in this research area

Year	<2017	2017	2018	2019	2020	2021	Total
Number of citations received	653	256	395	476	484	46	2310

Table 8: A citation analysis of the top ten publications in Astronomical Object Tracking in Scopus

Authors	**Title**	**Year**	**Source Title**	**Number of times Cited**
Markley F.L., Crassidis J.L.	“Fundamentals of spacecraft attitude determination and control”	2014	“Fundamentals of Spacecraft Attitude Determination and Control”	433
Leor Barack *et al*	“Black holes, gravitational waves and fundamental physics: A roadmap”	2019	“Classical and Quantum Gravity”	221
Hama T., Watanabe N.	“Surface processes on interstellar amorphous solid water: Adsorption, diffusion, tunneling reactions, and nuclear-spin conversion”	2013	“Chemical Reviews”	162
Feigelson E.D., Babu G.J.	“Modern statistical methods for astronomy: With R applications”	2009	“Modern Statistical Methods for Astronomy: With R Applications”	129
Kopeikin S., Efroimsky M., Kaplan G.	“Relativistic Celestial Mechanics of the Solar System”	2011	“Relativistic Celestial Mechanics of the Solar System”	129
Catling D.C., Kasting J.F.	“Atmospheric evolution on inhabited and lifeless worlds”	2017	“Atmospheric Evolution on Inhabited and Lifeless Worlds”	101
Longuski J.M., Guzman J.J., Prussing J.E.	“Optimal Control with Aerospace Applications”	2014	“Optimal Control with Aerospace Applications”	69
Turyshev S.G.	“Experimental tests of general relativity: Recent progress and future directions”	2009	“Physics-Uspekhi”	58
Konopliv A.S *et al*	“The Dawn gravity investigation at Vesta and Ceres”	2011	“Space Science Reviews”	56
Feistel R., Ebeling W.	“Physics of Self-Organization and Evolution”	2011	“Physics of Self-Organization and Evolution”	53

Conclusion:

With each progressing day, diverse modifications are being made to the Keplerian concepts and the study of various extra-terrestrial bodies. These findings have been merged with big data and data science algorithms which have enabled the industry to bring about some of the finest developments. From our survey, we have seen that machine learning techniques have been used not only for planet and trajectory detection but also to understand various factors that influence their motion and position. It has been evident that despite the various available telescopes and ray detectors, machine learning algorithms are robust and more accurate as compared to human visual examination. However, hardware utilization for the algorithms is equally important, and hence AIOT, that is AI with IoT has been developed for image detection and this formulation brings about 77% accuracy in its results for detection. The bibliometric analysis can be used by the budding researcher in the Astronomical Object Tracking research area about the influential authors, significant keywords, top affiliations, top journals, top funding agencies. Orbits, Asteroids, and Gravitation are the significant keywords used by the influential authors in their research work. The maximum publications are from the United States followed by Germany and France. Eight research papers have been published under the funding of the National Aeronautics and Space Administration. Maximum research is published in articles in Physics and Astronomy journal.

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