**Filaments**

**Constraints on distances to Galactic Centre non-thermal filaments from HI absorption Subhashis Roy?**

**2003**

**https://www.aanda.org/articles/aa/pdf/2003/21/aa2310.pdf**

An intriguing fact that has been noticed for all the wellstudied NTFs is the interaction between the NTF and molecular clouds (Morris & Serabyn 1996). It appears that the presence of an HII region near the place of interaction plays a role in the creation and maintenance of the NTFs (Serabyn & Morris 1994; Staguhn et al. 1998; Uchida & Guesten 1995). CO observations have indicated the presence of high velocity molecular clouds; −65 km s−1 and −130 km s−1 towards Sgr C (Liszt & Spiker 1995). It is believed that the HII region located just south of the NTF (known as the Sgr C HII region) is actually embedded in the −65 km s−1 cloud (Liszt & Spiker 1995; Kramer et al. 1998). Two dense molecular clouds are reported to be associated with the NTF G359.54+0.18. One of the clouds having a velocity of −140 km s−1 is located near the bent portion of the NTF (“E” in Fig. 8). The other cloud with a velocity of −90 km s−1 is located close to the eastern edge of the NTF (Staguhn et al. 1998). However, these reported associations are based on their proximity in the sky plane, and the spatial association of the corresponding objects has yet to be established.

HI absorption studies of three NTFs known as the Sgr C, G359.54+0.18 and G359.79+0.17 using the GMRT have yielded the following results: (a) For the first time, the Sgr C NTF and the HII region are shown to be located within a few hundred parsecs of the GC. (b) Our study indicates that the Sgr C HII region is either embedded in or located behind the −65 km s−1 molecular cloud, whereas the Sgr C NTF is located at the near side of the cloud, which argues against any possible interaction between the two objects. (c) A molecular cloud with a velocity of −100 km s−1 appears to be associated with the central part of the Sgr C NTF, and on the basis of the presently existing data, it appears that the magnetic pressure in the NTF is higher than the pressure due to the −100 km s−1 cloud. (d) HI absorption by the “3 kpc arm” is detected against all the three NTFs, which indicates that the NTF G359.54+0.18 and G359.79+0.17 are located at a minimum distance of 5.1 kpc from the Sun. (e) Weak HI absorption (4 σ level) at −140 km s−1 suggests that the NTF G359.54+0.18 is located at a minimum distance of ≈8.5 kpc from us. (f) The maximum distance of the NTF G359.54+0.18 and G359.79+0.17 is estimated to be 10.5 kpc from the Sun. The present study extends the number of NTFs that have been found to be located near the GC region to five. With most of the known NTFs now being shown to be near the GC, there remains little doubt that phenomena related to the central region of the Galaxy are responsible for the creation and maintenance of the NTFs.

**High-Resolution, Wide-Field Imaging of the Galactic Center**

**Region at 330 MHz**

**Michael E. Nord1**

**, T. Joseph W. Lazio, Namir E. Kassim**

**2004**

[**https://ui.adsabs.harvard.edu/abs/2004AJ....128.1646N/abstract**](https://ui.adsabs.harvard.edu/abs/2004AJ....128.1646N/abstract)

18 NTF candidates, 30 pulsar candidates, reveals previously

known extended sources in greater detail, and has resulted in the first detection

of Sagittarius A∗

in this frequency range.

An alternative idea is that the NTFs are magnetic wakes formed from the amplification

of a weak global field through a molecular cloud-galactic center wind interaction (Shore &

LaRosa 1999)

Though as of yet there is no consensus as to the origin of these structures, they are known

to be non-thermal in nature, and therefore high resolution studies at low radio frequencies

are important to understanding this phenomenon and for increasing the census of known

NTFs.

The orientation of the NTFs is of particular interest due to their potential to discriminate

between different NTF origin theories and for tracing Galactic Center magnetic fields. For

the purposes of this discussion, orientation will be defined as the separation angle between

the long axis of the NTF and the normal to the Galactic plane. The nine known isolated

NTFs are, with the exception of G358.85+0.47, nearly normal to the Galactic plane. This

observation supports the hypothesis that the magnetic field in the region is poloidal in nature

(e.g. Morris & Serabyn 1996, and references therein). However, the new NTF population

differs significantly with a mean orientation of 35◦ ± 40◦

. Furthermore, NTFs much closer

to the plane and to the Galactic Center than G358.85+0.47 such as NTF G359.22−0.16

are nearly parallel to the Galactic plane. This suggests that the Galactic Center magnetic

field is significantly more complicated than a simple dipole field. Though it noteworthy that

the brightest NTFs align normal to the plane, the new NTF population would appear to

imply an larger scale non-poloidal field and/or a disordered component of the magnetic field.

Moreover, the pseudo-random orientation of weaker candidate NTFs may indicate a physical

manifestation not directly connected to the properties of any global field.

**A Nonthermal Radio Filament Connected to the Galactic Black Hole? Mark R. Morris1 , Jun-Hui Zhao2 , and W. M. Goss3**

**2017**

[**https://iopscience.iop.org/article/10.3847/2041-8213/aa9985/pdf**](https://iopscience.iop.org/article/10.3847/2041-8213/aa9985/pdf)

Using the Very Large Array, we have investigated a nonthermal radio filament (NTF) recently found very near the Galactic black hole and its radio counterpart, Sgr A\* . While this NTF—the Sgr A West Filament (SgrAWF)— shares many characteristics with the population of NTFs occupying the central few hundred parsecs of the Galaxy, the SgrAWF has the distinction of having an orientation and sky location that suggest an intimate physical connection to Sgr A\*

Assuming that the SgrAWF bears a physical relationship to Sgr A\* , we examine the potential implications. One is that Sgr A\* is a source of relativistic particles constrained to diffuse along ordered local field lines. The relativistic particles could also be fed into the local field by a collimated outflow from Sgr A\* , perhaps driven by the Poynting flux accompanying the black hole spin in the presence of a magnetic field threading the event horizon.

Second, we consider the possibility that the SgrAWF is the manifestation of a low-mass-density cosmic string that has become anchored to the black hole. The simplest form of these hypotheses would predict that the filament be bi-directional, whereas the SgrAWF is only seen on one side of Sgr A\* , perhaps because of the dynamics of the local medium. A more exotic interpretation of SgrAWF is a superconducting cosmic string. As Chudnovsky et al. (1986) have argued, light, superconducting, cosmic string loops would migrate toward the center of a Galaxy by frictional deceleration resulting from shock dissipation of their relative velocity as they interact electromagnetically with the magnetized interstellar plasma

they delineate the local magnetic field lines and that the field is highly ordered on large scales (e.g., Morris 2014)

Many of the NTFs show filamentary substructure—a doubling of the filamentary strands, or even in some cases a tightly packed bundle of parallel filaments.

Until recently, no NTF had yet been found within the central parsec, but Yusef-Zadeh et al. (2016) recently presented radio images of a bent filament located 0.25–0.75 pc north of Sgr A\* , and one of the suggestions they made for the nature of this feature was that it might be a member of the NTF population. However, they were not able to demonstrate that the filament is a nonthermal feature because of the difficulty of obtaining its spectral index in this complex region. Yusef-Zadeh et al. (2016) noted that the bent filament extends toward Sgr A\* , but could not be followed closer to Sgr A\* than about 5 arcsec.

A small minority of other filaments show such a bending (e.g., the “Snake”; Gray et al. 1995), which can be attributed to a large localized stress that has deformed the magnetic field that the filament is following. s. A candidate mechanism for bending the SgrAWF would be an oblique shock. Indeed, a shock front near the location of the bend in the SgrAWF has been proposed by Rockefeller et al. (2005), who interpret an X-ray emission ridge as the standoff shock occurring between the blast wave from the nearby supernova remnant, Sgr A East, and the collective winds from the massive stars in the central young star cluster. The bend in the SgrAWF is located just inside the poorly defined X-ray ridge, toward Sgr A\* , so it could coincide with the leading edge of the advancing shock.

all NTFs are necessarily associated with a source of relativistic electrons (or perhaps positrons) somewhere along their length (e.g., Morris 1996), and for the SgrAWF, the proximal, accreting supermassive black hole is an obvious candidate for producing such particles. These considerations lead us to consider the ways in which the NTF could be physically related to Sgr A\*

One possibility is therefore that the emitting relativistic particles in the filament are generated by the release of accretion energy in the near vicinity of Sgr A\* .

**DEEPSOURCE: point source detection using deep learning A. Vafaei Sadr,1,2,3‹ Etienne. E. Vos,2,4,5 Bruce A. Bassett,2,3,5,6 Zafiirah Hosenie,2,5,7 N. Oozeer 2,3 and Michelle Lochner2,3**

**2019**

[**https://watermark.silverchair.com/stz131.pdf?token=AQECAHi208BE49Ooan9kkhW\_Ercy7Dm3ZL\_9Cf3qfKAc485ysgAAArowggK2BgkqhkiG9w0BBwagggKnMIICowIBADCCApwGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMZlRIJc6r9LUiVqZaAgEQgIICbaDZRIDQ30oH3jRFdfit\_j-Ps\_\_5pcdE-Am70-UmOw\_bSXD\_9MaKee0Bg1X637Lc8SIrkHP\_5IjjRjakcxsd7X5FPK3NxHNJipjtUO-fEojrWTpv2rsvXY78aPE9tCJ7A5jkWDkcLdCKluwxz-gslFLhdJ0ucjVjyEa8KcZ5yvp17CMQLFyTe8QaPW\_hyv5-6cvu3bHTRzhwCyBL2drhz\_KKHVc-n1kCJ8N5\_lyY645Limh6GMe1iyyzg\_jWeheHtcQpeaedGnU9ScOQ\_2rPABzeZqjvSK2MskPyi7yI4qURI7mdeu3Z-YHm5HqUOfarH2xrWgCGCGjxwJq\_6qNZJV9si-QVe0xBTC\_5i1kcsAe5nEFMQlmHW-tB5e6IQZbOGvD0\_WnY56agyOfDGj\_pNvr41GYrHY\_mZBbWGp\_91sCJ85Ybxfaj1ltMtNchuUaKUeU2ke55GoIRGo4u52WJ49R0q72jV3bjiABvsYfABm5XZPQyQE7DhTdKVVk7o9jJ\_jgWKa6RgMjmwdVVK9mldmqgZzfBpiJLiCdjz4K9M7BqGNWK32Z4YeysTs9\_H7Ews34PjdCcM3hswQzoTH6Uo80L-yIijKEpVsa6-K4RksMfQtlYekQAC3Xl9HfA0KeFLwI1E5cpeoKX9O0Sagb\_pit1vWXhzZE2Wr74ztOZHAwThP4x5sSrqs2FOe\_bwLPdcsXka5hqRetFY-ZiP9Y529ni2LaVX\_c8hMNTK0WpxpwYV4IA9m\_XuFIltNYRJeL1IIwolfvyfyEmRsA9Ks1O6kcaO\_BqrcBS4bTuLfB6EL7z-gVwAfvRAy-udnAXNg**](https://watermark.silverchair.com/stz131.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAArowggK2BgkqhkiG9w0BBwagggKnMIICowIBADCCApwGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMZlRIJc6r9LUiVqZaAgEQgIICbaDZRIDQ30oH3jRFdfit_j-Ps__5pcdE-Am70-UmOw_bSXD_9MaKee0Bg1X637Lc8SIrkHP_5IjjRjakcxsd7X5FPK3NxHNJipjtUO-fEojrWTpv2rsvXY78aPE9tCJ7A5jkWDkcLdCKluwxz-gslFLhdJ0ucjVjyEa8KcZ5yvp17CMQLFyTe8QaPW_hyv5-6cvu3bHTRzhwCyBL2drhz_KKHVc-n1kCJ8N5_lyY645Limh6GMe1iyyzg_jWeheHtcQpeaedGnU9ScOQ_2rPABzeZqjvSK2MskPyi7yI4qURI7mdeu3Z-YHm5HqUOfarH2xrWgCGCGjxwJq_6qNZJV9si-QVe0xBTC_5i1kcsAe5nEFMQlmHW-tB5e6IQZbOGvD0_WnY56agyOfDGj_pNvr41GYrHY_mZBbWGp_91sCJ85Ybxfaj1ltMtNchuUaKUeU2ke55GoIRGo4u52WJ49R0q72jV3bjiABvsYfABm5XZPQyQE7DhTdKVVk7o9jJ_jgWKa6RgMjmwdVVK9mldmqgZzfBpiJLiCdjz4K9M7BqGNWK32Z4YeysTs9_H7Ews34PjdCcM3hswQzoTH6Uo80L-yIijKEpVsa6-K4RksMfQtlYekQAC3Xl9HfA0KeFLwI1E5cpeoKX9O0Sagb_pit1vWXhzZE2Wr74ztOZHAwThP4x5sSrqs2FOe_bwLPdcsXka5hqRetFY-ZiP9Y529ni2LaVX_c8hMNTK0WpxpwYV4IA9m_XuFIltNYRJeL1IIwolfvyfyEmRsA9Ks1O6kcaO_BqrcBS4bTuLfB6EL7z-gVwAfvRAy-udnAXNg)

Point source detection at low signal-to-noise ratio (SNR) is challenging for astronomical surveys, particularly in radio interferometry images where the noise is correlated. Machine learning is a promising solution, allowing the development of algorithms tailored to specific telescope arrays and science cases

Traditionally, in radio astronomy, one extracts the noise (rms; σ) from a ‘sourcefree’ region (Subrahmanyan et al. 2000; Mauch et al. 2013) and then identifies sources as those peaks above a threshold (Carbone et al. 2018), often taken to be 3σ, depending on the image quality. Next a Gaussian would be fitted to the source and the respective parameters extracted. This was the strategy of the original Search And Destroy algorithm, as implemented in AIPS.1 Although source

finding has evolved and several variants developed, most of these methods suffer from the problem that the choice of the location and size of the region used for estimating the noise is susceptible to contamination from faint point sources, which can lead to biases in source counts due to false positives and false negatives, especially at SNR < 5, but sometimes even at an SNR < 10 (see Hopkins et al. 2015). Moreover, the big data challenges posed by upcoming massive astronomical facilities such as the Square Kilometre Array (SKA) will require robust and fast source detection algorithms to leverage the full potential of the large images that will be produced.

**2 mm GISMO Observations of the Galactic Center. II. A Nonthermal Filament in the Radio Arc and Compact Sources\* Johannes Staguhn1,2 , Richard G. Arendt1,3 , Eli Dwek1 , Mark R. Morris4 , Farhad Yusef-Zadeh5 , Dominic J. Benford**

**2019**

**https://iopscience.iop.org/article/10.3847/1538-4357/ab451b/pdf**

Suggest the NTF is connected to a ionized gas cloud

Detect thermal emission from cold interstellar medium dust, thermal free–free emission from ionized gas, and nonthermal synchrotron emission from relatively flat-spectrum sources. Archival data sets spanning 3.6 μm–90 cm are used to distinguish different emission mechanisms. After the thermal emission of dust is modeled and subtracted, the remaining 2 mm emission is dominated by free–free emission, with the exception of the brightest nonthermal filament (NTF) that runs through the middle of the bundle of filaments known as the Radio Arc. This is the shortest wavelength at which any NTF has been detected. The GISMO observations clearly trace this NTF over a length of ∼0°. 2, with a mean 2 mm spectral index that is steeper than at longer wavelengths. The 2 mm–6 cm (or 20 cm) spectral index steepens from α ≈ −0.2 to −0.7 as a function distance from the Sickle H II region, suggesting that this region is directly related to the NTF

A number of models have considered the origin of NTFs associated with molecular clouds or with mass-losing stars (e.g., Rosner & Bodo 1996; Shore & LaRosa 1999; Bicknell & Li 2001). However, there is no consensus on the origin of the Galactic center filaments. Among the large number of known NTFs, a bundle of filaments near the Radio Arc at l ∼ 0°. 2 is unique in its physical interaction with the molecular cloud G0.13–0.13 (Tsuboi et al. 1997). In addition, these filaments are surrounded by ionized gas, and have an unusually flat spectrum for a nonthermal polarized source.

The brightest NTF in the Radio Arc is detected at 2 mm with a brightness that is consistent with a steep spectral index (α ≈ −1.5) at 2 mm. The steepening 2 mm spectral index as a function of location along the NTF points to the Sickle (rather than point source N3) being directly related to the origin on the NTF electrons. Interpretation of the changing spectral index as the aging of populations of relativistic electrons implies timescales of ∼5000 yr and velocities of ∼6100 km s−1 for diffusion of relativistic electrons along the NTF. The rest of the Radio Arc is only marginally detected.

**Nonthermal Filaments from the Tidal Destruction of Clouds in the**

**Galactic Center**

**Eric R. Coughlin, 1★ C. J. Nixon, 2 Adam Ginsburg3**

**2021**

[**https://ui.adsabs.harvard.edu/link\_gateway/2021MNRAS.501.1868C/EPRINT\_PDF**](https://ui.adsabs.harvard.edu/link_gateway/2021MNRAS.501.1868C/EPRINT_PDF)

Synchrotron-emitting, nonthermal filaments (NTFs) have been observed near the Galactic center for nearly four decades, yet

their physical origin remains unclear. Here we investigate the possibility that NTFs are produced by the destruction of molecular

clouds by the gravitational potential of the Galactic center. We show that this model predicts the formation of a filamentary

structure with length on the order of tens to hundreds of pc, a highly ordered magnetic field along the axis of the filament,

and conditions conducive to magnetic reconnection that result in particle acceleration. This model therefore yields the observed

magnetic properties of NTFs and a population of relativistic electrons, without the need to appeal to a dipolar, ∼ mG, Galactic

magnetic field. As the clouds can be both completely or partially disrupted, this model provides a means of establishing the

connection between filamentary structures and molecular clouds that is observed in some, but not all, cases.

However, more recent observations

of shorter filaments and their less ordered distribution (property

4) suggest that, if NTFs do indeed trace the GC magnetic field, it may

not be so well-ordered.

LaRosa et al. (2005) found that the diffuse,

nonthermal emission originating from the GC implies a relatively

weak field (∼ tens of 𝜇G) compared to the large (∼ mG) values

inferred in filaments (Morris & Serabyn 1996), the latter inference

based upon the assumption that the magnetic field pressure within a

filament must balance the turbulent ram pressure of the GC gas to

maintain its linear morphology; more recent observations of molecular

lines suggest Galactic magnetic field strengths on the order of

∼ 100 𝜇G (Oka et al. 2019). Yusef-Zadeh et al. (2005), assuming inverse

Compton scattering was producing X-rays in one NTF, inferred

a magnetic field strength of ∼ 80𝜇G within that filament, while Gray

et al. (1995) found from Faraday rotation that the immediate vicinity of the filament G359.1-00.2, or the “Snake,” is characterized by a

∼ 10𝜇G field. These latter measurements contrast the strong fields

based on dynamical arguments.

In addition to the strength and origin of the filamentary magnetic

fields, a separate (but not unrelated) puzzle concerns the origin of

the filaments themselves. Gray et al. (1995) (see also Bicknell & Li

2001a) delineated a number of formation mechanisms for the Snake,

including shock fronts, star wakes, and cosmic strings, and concluded

that none is particularly well-suited for explaining all of its properties.

Others have investigated the interaction between fast-moving clouds

and a pre-existing magnetic field as a possible origin (e.g., Benford

1988; Staguhn et al. 1998), and some have argued that filaments can

be generated as a consequence of the collision between stellar winds

in star-forming regions (e.g., Rosner & Bodo 1996; Yusef-Zadeh

2003). More recently it has been suggested that an outflow, or wind,

emanating from the GC could interact with giant molecular clouds

and produce filamentary structures (e.g., Banda-Barragán et al. 2018;

Yusef-Zadeh & Wardle 2019). The radio observations of the GC by

MeerKAT (Heywood et al. 2019) indicate that some of the most extended

filamentary structures (the “Arc”) arise coincidently with the

longitudinal extremities of inflated radio bubbles, and are therefore

likely edge-brightened emission from that same, large-scale source

(see Figure 2 of Heywood et al. 2019)

While edge brightening of the radio bubbles appears to be a likely

explanation for the Arc, the numerous other, smaller filaments – at

least dozens in number from Figure 2 of Heywood et al. 2019 – do

not seem to be at least directly related to this phenomenon. Here

we analyze a distinct model for the origin of these filaments, being

the destruction of a molecular cloud by the tides of the Galactic

potential (dominated by the SMBH at sufficiently small radii; see

Section 2 below). This model – in the limit that the SMBH dominates

the potential – was originally proposed by Ekers et al. (1983) and

analyzed quantitatively and numerically by Quinn & Sussman (1985)

and Sanders (1998), and has been more recently considered in the

context of star formation in the GC (Bonnell & Rice 2008; Alig

et al. 2011)

We show that under different (and probably more likely)

circumstances, the destruction of a gas cloud by a SMBH creates

a nearly linear filament with a magnetic field oriented parallel to

its axis. Moreover, while the prediction of this model is that the

orientation of the field should be along the filament axis, the sign of

the field is not necessarily the same everywhere within the filament;

this model therefore also predicts that there should be regions within

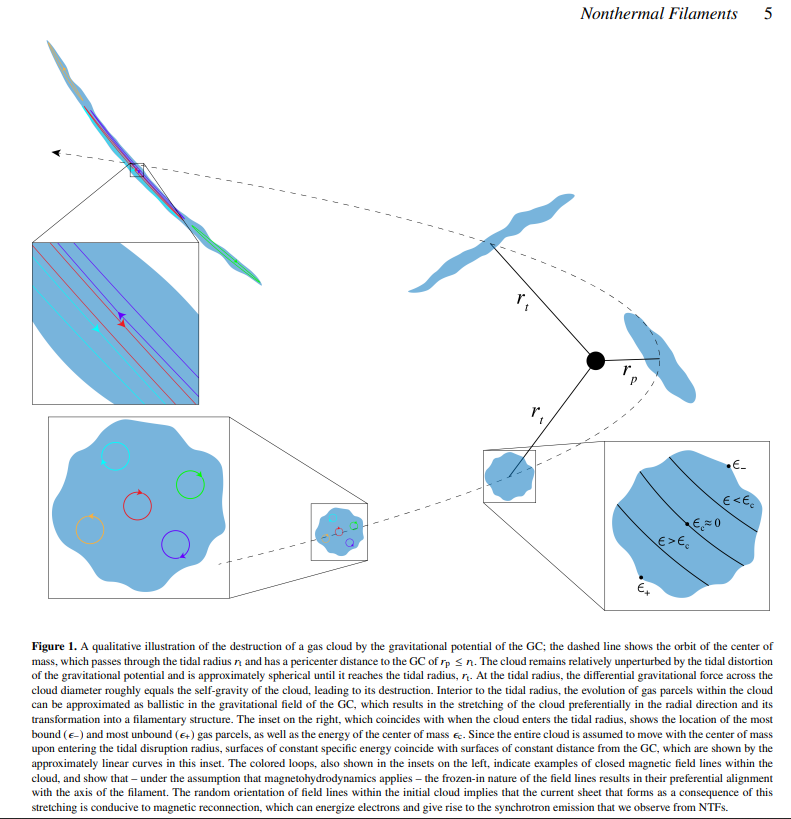
the filament that contain nearly parallel lines of magnetic field but

with opposing signs, which generate current sheets that are conducive

to reconnection and particle acceleration. In addition to providing an

ordered field, this formation mechanism therefore also establishes a

means of nonthermal particle acceleration.



While these explanations hint at the notion that the substructure and multiplicity of filaments is only apparent, a number of closely spaced filaments could arise from substructure within the original cloud.

but multiple over-densities could exist within the cloud, each with a tidal radius smaller than that of the cloud on average. In this case, one would expect each high-density pocket to remain relatively intact until it reaches its own tidal radius, which would eventually occur for a sufficiently large value of 𝛽 of the cloud COM. In this case and with a range of over-densities each with its own tidal disruption radius, each pocket of dense material would be disrupted in relatively close temporal succession, resulting in the formation of multiple filaments with similar spatial orientation and overall extent.

**ML w/ Astronomy**

**Supernovae Detection by Using Convolutional Neural Networks Guillermo Cabrera-Vives\*tt , Ignacio Reyes§\*, Francisco Forstert\*, Pablo A. Estevez§\* and Juan-Carlos Maureirat**

[**https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7727206**](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7727206)

**2016**

Abstract-During the last couple of years Astronomy, as many other fields, has been facing the problem of automatic processing of massive data. This has been primarily driven by large survey instruments, which scan large areas of the sky aiming to catalog everything they find. The High Cadence Transient Survey (HiTS) is one of these surveys that searches for phenomena of limited duration (such as supernovae) called transients. The HiTS pipeline produces transient candidates by subtracting science images from a template. In this paper we present a convolutional neural network (ConvNet) approach to classify sources found in the difference images as real transients or artifacts. We compare our results against a random forest classification model that has been created by the HiTS team during the last two years through feature engineering. Our ConvNet model obtains features automatically and obtains a 99.32% accuracy as compared to the previous 98.89% accuracy from the random forest model. This approach will be very useful when processing data from next generation instruments such as the Large Synoptic Survey Telescope (LSST).

For 2022 we expect to have the Large Synoptic Survey Telescope (LSST, [4]) operative, which will scan the whole southern sky every couple of days.

Historically, astronomers have used eyeball classification in order to detect transient events. Recently ML has been used in the data pipeline to filter some of the images which the CNN has dejected to be bogus images. Feature maps are usually designed by a scientist. Usually, in order to define the features to be used, there is an important amount of work to be done by the scientist in order to understand representative features for the problem to be solved.

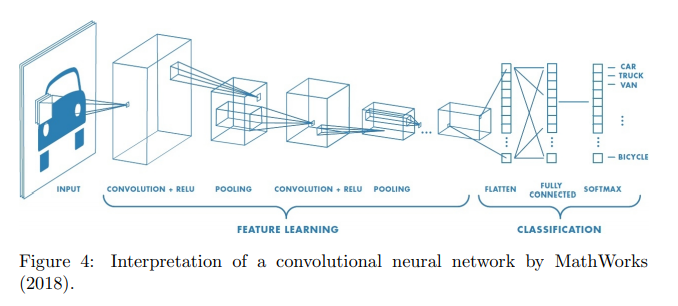
only recently they have gained attention in Astronomy related problems, thanks to the Galaxy Zoo Challenge. This challenge aimed to estimate galaxy morphologies out of images using data from Galaxy Zoo 2

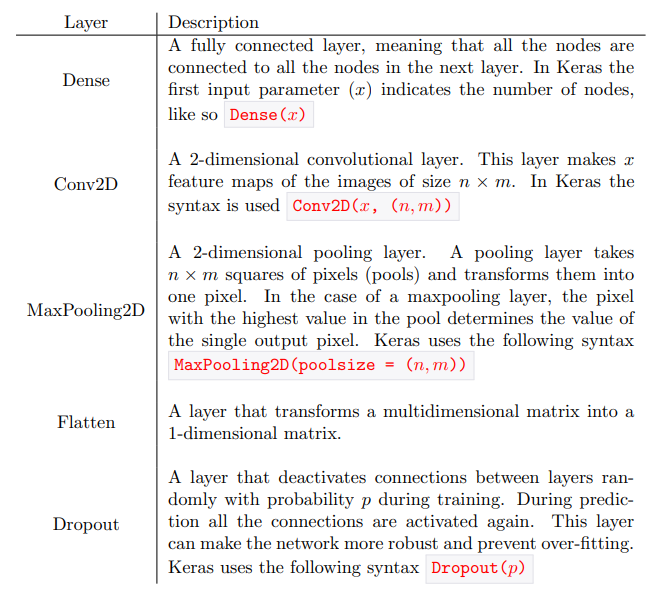
The overlapping between convolutions is defined by the stride (distance between receptive fields center of neighboring neurons).

<https://fse.studenttheses.ub.rug.nl/17826/1/thesis.pdf>

Adam optimizer has proven to be a very efficient optimizer for most problems (Kingma and Ba, 2014)

The value for the output pixel can be the minimum, average or maximum of the pool, called minpooling, average pooling and maxpooling respectively. If we would take a pooling size of 2 × 2, this means that the resulting image would be 4 times as small as the input, because it is halved vertically and horizontally





**Galaxy Classifications with Deep Learning**

**Lukic, Vesna; Brüggen, Marcus**

**2017**

[**https://ui.adsabs.harvard.edu/abs/2017IAUS..325..217L/abstract**](https://ui.adsabs.harvard.edu/abs/2017IAUS..325..217L/abstract)

Machine learning techniques have proven to be increasingly useful in astronomical

applications over the last few years, for example in object classification, estimating redshifts

and data mining. One example of object classification is classifying galaxy morphology. This is

a tedious task to do manually, especially as the datasets become larger with surveys that have a

broader and deeper search-space. The Kaggle Galaxy Zoo competition presented the challenge of

writing an algorithm to find the probability that a galaxy belongs in a particular class, based on

SDSS optical spectroscopy data. The use of convolutional neural networks (convnets), proved to

be a popular solution to the problem, as they have also produced unprecedented classification

accuracies in other image databases such as the database of handwritten digits (MNIST †)

and large database of images (CIFAR ‡). We experiment with the convnets that comprised the

winning solution, but using broad classifications. The effect of changing the number of layers is

explored, as well as using a different activation function, to help in developing an intuition of

how the networks function and to see how they can be applied to radio galaxy images.

The winning solution to the competition used convnets (Dieleman et al. 2015). With

regards to machine learning with galaxy images, the convnet approach has mainly been

taken on optical galaxy images, and it has only very recently started to take place on

radio galaxy images (Alger 2016). This work aims to develop a convnet to classify radio

galaxies according to some classification scheme, such as Fanaroff-Riley (Fanaroff & Riley

1974).

In traditional neural networks, the nodes in the hidden layers are fully connected to

the nodes in the adjacent layers. Therefore, the deeper the network becomes, the more

computationally intensive and time consuming it is to train, and the propagated gradient

becomes smaller with every added layer, leading to the vanishing gradient problem. This

stalls the training loss, hence prevents the network from learning further. Convolutional

neural networks circumvent this problem, by introducing a number of user-defined filters

with initialised weights and biases, that are connected to a small spatial region of the

input data. This greatly reduces the number of connections, hence the network is easier

and faster to train. The amount of data in the convolutional layers is further reduced

by using a pooling layer, where only the maximum output in a certain region is stored.

The convolutional and pooling layers are stacked with the end result being a hierarchical

extraction of features. These layers are usually followed by one or more fully-connected

layers, before finishing at the output layer, where a prediction is given (Karpathy 2016).

image augmentation can be used to artificially

produce more image data (Krizhevsky et al. 2012). In the case of galaxy images,

augmentation can be done through transformations such as rotation and translation, as

they are invariant to these. (Dieleman et al. 2015).

*(My network uses binary Cross entropy)*

**

*where y is the label (1 for green points and 0 for red points) and p(y) is the predicted probability of the point being green for all N points.*

*Reading this formula, it tells you that, for each green point (y=1), it adds log(p(y)) to the loss, that is, the log probability of it being green. Conversely, it adds log(1-p(y)), that is, the log probability of it being red, for each red point (y=0).*

[*https://towardsdatascience.com/understanding-binary-cross-entropy-log-loss-a-visual-explanation-a3ac6025181a*](https://towardsdatascience.com/understanding-binary-cross-entropy-log-loss-a-visual-explanation-a3ac6025181a)

**Radio Galaxy Zoo: Compact and extended radio source classification with deep learning V. Lukic,1? M. Bruggen, ¨ 1† J.K. Banfield,2,3 O.I. Wong,4,3 L. Rudnick,6 R.P. Norris,5,9 B. Simmons7,**

**2018**

[**https://arxiv.org/pdf/1801.04861.pdf**](https://arxiv.org/pdf/1801.04861.pdf)

Machine learning techniques have been increasingly useful in astronomical applications over the last few years, for example in the morphological classification of galaxies. Convolutional neural networks have proven to be highly effective in classifying objects in image data. The current work aims to establish when multiple components are present, in the astronomical context of synthesis imaging observations of radio sources. To this effect, we design a convolutional neural network to differentiate between different morphology classes using sources from the Radio Galaxy Zoo (RGZ) citizen science project. In this first step, we focus on exploring the factors that affect the performance of such neural networks, such as the amount of training data, number and nature of layers and the hyperparameters. We begin with a simple experiment in which we only differentiate between two extreme morphologies, using compact and multiple component extended sources. We found that a three convolutional layer architecture yielded very good results, achieving a classification accuracy of 97.4% on a test data set. The same architecture was then tested on a four-class problem where we let the network classify sources into compact and three classes of extended sources, achieving a test achieving a test accuracy of 93.5%. The best-performing convolutional neural network setup has been verified against RGZ Data Release 1 where a final test accuracy of 94.8% was obtained, using both original and augmented images. The use of sigma clipping does not offer a significant benefit overall, except in cases with a small number of training images.

The convolutional neural network approach has only very recently started to be applied to radio galaxy images. One example has been in using convolutional neural networks to infer the presence of a black hole in a radio galaxy (Alger 2016). Another example is in a recently published paper by Aniyan & Thorat (2017), where the authors present their results on classifying radio galaxy images using convolutional neural networks into the classes of Fanaroff & Riley Type 1 or 2 (FRI/ FRII) (Fanaroff & Riley 1974) and benttailed radio galaxies using a few hundred original images in each class and producing a highly augmented dataset.

the authors have commented on issues with regards to overfitting due to having few representative samples in each class prior to augmentation, resulting in a small feature space and the fact that the network was highly sensitive to the preprocessing done to the images.

We found that the three convolutional and two dense layer architecture using the original and augmented images with no sigma clipping produced the maximal accuracy of 97.4%

When training deep neural networks with a large enough number of images, removing noise through the use of sigma clipping appears to offer no significant benefit.

**A deep learning approach for detecting candidates of supernova remnants Wei Liu1 , Meng Zhu1 , Cong Dai1 , Bing-Yi Wang1 , Kang Wu1 , Xian-Chuan Yu1 , Wen-Wu Tian2 , Meng-Fei Zhang2 and Hong-Feng Wang**

**2019**

[**https://iopscience.iop.org/article/10.1088/1674-4527/19/3/42/pdf**](https://iopscience.iop.org/article/10.1088/1674-4527/19/3/42/pdf)

In addition, transfer learning is used to initialize the network parameters, which improves the speed and accuracy of network training.

f k learned filters (or kernels), which have a small receptive field. In this work, each filter is convolved across the width and height of the input volume, computing the dot product between the entries of the filter and the input, and then producing an activation map of that filter: y = X k i=1 Wi ∗ x + b , (9) where W are the weights, ∗ is a convolution operator, b is a bias parameter, and y is the output feature map.

The pooling layer is used to gradually reduce the size of the representation space, the number of parameters, and the computation time in the network and also prevents over-fitting. The output of the network is classifier Softmax. A subset of features is selected as the input vector of Softmax for training and recognition.