MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

A snapshot of Postgraduate Research 2023

PGR Writing Competition

ADDRESS FROM DEAN OF GRADUATE STUDIES

As our postgraduate research students live and work in an increasingly digital and information-driven age, the ability to write and communicate in a variety of styles appropriate to a range of audiences becomes increasingly important.

The Graduate Studies Office working with the MTU Library Service and others, supports research students to develop their writing skills not just for academic publication but also for communicating to the general public. As part of this initiative, we organized the second annual MTU Postgraduate Research Writing Competition. Its aim was to provide postgraduate research students from all disciplines across the University with an opportunity to develop their writing skills and communicate their research, in language appropriate to a non-specialist audience and to the wider society.

Students were asked to submit a written article of no more than 500 words. The writing to take on any form, but the piece to be original, solely the work of the author and not published anywhere else in any format. A judging panel assessed the entries on the basis of three judging criteria: content, clarity and creativity.

The Graduate Studies Office would like to thank the judging panel: Dr Breda Dwyer, Head of CEED and Senior Lecturer in Entrepreneurship and Regional Sustainability, Kerry Campus; Professor John Barrett, NIMBUS Research Centre and Dr Catherine Frehill, Dept of Physical Sciences, for their time and expertise in judging this competition.

This compendium comprised of submissions from across all domains of the MTU research landscape including the Creative Arts (Fine Art, Music); Humanities (Social Studies), Sciences (Life Sciences, Computer Sciences and Physical Sciences) together with a number of entries from the various Engineering disciplines. This compendium presents, in the words of our students, a fascinating snapshot of research being undertaken in MTU today.

Dr Stephen Cassidy
Dean of Graduate Studies and Academic Quality Enhancement

EXTRA! EXTRA! A NEW CONTENDER ENTERS THE RING!

Staphylococcus aureus vs Bacteriocins

Written by: **Dr Ellen Twomey, PhD**
Department of Biological Sciences

We welcome our avid readers back to the on-going coverage of the 'Antimicrobial Resistance' League Tournament, (the fight against infection-causing bacteria resistant to antibiotics). Today's special feature is dedicated to the infamous bridge-weight champion – Staphylococcus aureus. Ranking fifth in the global 'Top Ten Priority Pathogens' board, S. aureus made a name for itself in the 1950's as one of the first bacteria to demonstrate penicillin resistance. As of 2022 it is predicted to be responsible for approximately 100,000 deaths annually, with no sign of throwing in the towel. Even following the COVID-19 pandemic, which halted training for many other pathogenic agents, S. aureus associated-infections are back and hitting harder than ever.

Previous bets were placed on vancomycin and methicillin, powerful antibiotic contenaders, to shake up the ranking and supress S. aureus's rapid ascent to the top. However, recent bouts have indicated that even these last line of defence drugs, applied only in the direst circumstances, may not last many more rounds in the ring due to formidable counterstrategies developed by S. aureus (i.e. methicillin and vancomycin resistance). The brutal determination of this pathogen to adapt and stay in the fight has lead to the need to explore alternative pathways to bring down this would-be king.

While S. aureus appears to be on the up-and-up, speculation surrounding some new antimicrobial opponents with a novel attack style has been growing. Bacteriocins are small peptides which like antibiotics, are produced by bacteria and inhibit the growth of competitors occupying the same niches. Reports indicate they target key structural elements, placing blows S. aureus is seemingly unable to deflect.

One bacteriocin in particular, 'nisin', has repeatedly brought down staphylococcal combatants, including those of the resistant variety, during in vitro and in vivo trials. With previous experience as an organic preservative against Listeria monocytogenes, and pending sign-off from the FDA for use against veterinary pathogens, could nisin be the one to turn the tide against this pathogenic ring legend?

Financial backers seem to think so. Headlines were made in December of 2022 when University College Cork, (a long-time backer of nisin), received funding from the European Research Council to bring bacteriocin brawlers up to the standards of the sanctioning bodies before weigh in. It is hoped through this continued development and sponsoring of facilities, bacteriocins will one day be able to compete in the big leagues.

While reports like this seek to highlight the efficacy of bacteriocins against resistant bacterial titans, and hint that even those at the top might fall, only time will tell how the fated fight between nisin and S. aureus will playout. With nothing to lose and everything to gain, nisin although the underdog is seen by many as a legitimate challenger. Despite decades landing jabs, S. aureus is by no means faded and is still throwing its weight around. It is these odds, dear reader, which keep me glued to the game.

Tune in for further reporting on the developing dual between bacteria and the antimicrobials trying to defeat them. Until next time.

IN SEARCH OF LOST SHEEP

Using genetics to improve the fertility of the Irish sheep flock

Written by: **Rory McAuley, PhD candidate**
Department of Biological Sciences

My research involves looking for sheep which do not exist. No, I have not gone mad in the hills of Connemara, the toll of writing my dissertation having finally tipped me over the edge. I am a geneticist, and I am looking for traces of missing sheep in the DNA of their living relatives. Allow me to explain.

Each individual has two copies of each gene, one of which they inherit from their mother and one of which they inherit from their father. These copies (alleles) can either be dominant (usually good) or recessive (usually bad). Using genetic data, we can calculate how often we expect to see each of these good and bad alleles we in the national flock. Occasionally, certain combinations of alleles do not appear as often as we might expect.

Sheep are kept within breeds which have distinct physical features. So that these features might be maintained, closely related sheep are often interbred. However, as the royal families of Westeros (or Europe) can attest, breeding with close relatives for generations on end can cause a few issues. The most important of these is the accumulation of recessive alleles in the genome.

Closely related individuals are genetically very similar, and because of that they will share many of the same recessive alleles. Therefore, if two close relatives' mate then their offspring can inherit one recessive allele from their mother and one recessive allele from their father. The knock-on effects of carrying two recessive alleles at a gene can be catastrophic. Thankfully, inbreeding is rare in human beings, but in livestock it is rampant.

This is where the missing sheep come back into the picture. For some genes, there are far fewer sheep carrying two recessive alleles than we would expect, and sometimes there are no such individuals. These are my missing sheep, and we assume that they are missing because the effects of carrying two bad copies of that gene are fatal.

This is all very well and good, you might say, but what is the point of looking for missing sheep when there are plenty of unmissing sheep who might be of greater concern? These missing sheep are important because they represent lost fertility and missed opportunities for economic gain on Irish farms; it is estimated that every 1% change in lamb mortality nationally is worth €3 million to Irish farmers annually.

By identifying those genes where there are missing sheep, we can take action to lower lamb mortality on Irish farms. If a sheep carries two bad copies of a gene, it is because its parents each carried at least one. By identifying such sheep (we call these animals 'carriers') then farmers can stop them from reproducing with each other. This will ensure that each animal has at least one good copy of that gene, and it will resolve the problem of the missing sheep.

SPOTIFY FOR GENETIC ENGINEERING

Written by: **Daniel Keaney, PhD candidate**
Department of Biological Sciences

WHERE SLEEPING SEEDS LIE

Using the natural seed bank to restore or rewild

Written by: **Sally Griffin, PhD candidate**
Department of Biological and Pharmaceutical Sciences

In the face of looming climate change, environmental destruction, and biodiversity loss it is only right to want to have a positive impact, to transform your small patch into a miniature wilderness. With how available wildflower seed mixes and seed bombs are, who could resist?

But did you know that there is already a wild seed mix right under your nose? You may have heard of the Millennium seed bank at Kew Gardens in the UK, a very literal bank of seeds stored so that they may be used to recreate their natural habitats in the future (Anon., 2023). However, I am more focused on the natural seed bank that every habitat already has, the one you can access. These seed banks are the seeds in the soil, the bark of trees or floating in a stream that are just waiting for the right conditions to grow (Csontos, 2007).

Seeds are tough little things. Sometimes they're so tough that 32,000 years after squirrel buries them in the soil for the winter, scientists can find them and grow ancient flowers (Yashina et al., 2012).

OK, so most seeds won't last 32,000 years... or even decades (Csontos, 2007). However, more than likely your lawn or grassy verge or silage field is more diverse than it looks. Let's take a look at the silage field, which was probably fertilized and mown twice a year. There might only be a few plant species present that you can see; one or two grasses and a clover, which isn't the best when it comes to feeding the local wildlife. In the soil of that field is a lot more than two grasses and a clover though. There could be seeds of plantains, ox-eye daisy, two or three species of buttercup, vetches, tens of grasses, rushes and maybe even an orchid if we're really lucky. All of which can be important food sources for pollinators, birds and rodents at different times of year (Fuhlendorf and Engle, 2001, Anon., 2022).

All this is to say, you might not need to bomb your garden with seeds quite yet. Instead, putting off mowing to once or twice a year and leaving off fertilizer altogether will create the right conditions over time. As for the part of the garden that your dog dug up, it may seem a waste to leave a bare patch of soil but it may be full of life, with seeds that are simply sleeping and just need to be given a chance to wake up.

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VALUE RECYCLING FROM BIO-WASTE STREAMS

A perspective insight into biowaste management and existing potential for recovering value-added agro-products while closing the circular economy loop.

Written by: **Shon George Shiju, PhD candidate**
Department of Biological and Pharmaceutical Sciences

The Challenge

One man's trash is another man's treasure; I am sure you all would have heard this saying at some point in your life or have even been lucky to experience it in some form. Despite the phrase's popularity, it is often neglected, literally, when it comes to our trash. We currently live in a **'take-make-use-trash'** state termed linear economy *(Figure 1)*. In fairness, this linear model has started to change shape recently, but generally, waste generated is dealt with by ignorance and disgust.

Figure 1: The Linear economy model change shape recently, but generally, waste generated is dealt with by ignorance and disgust.

Nevertheless, when potential value is identified, waste gets praised and labelled as a by-product or feedstock. The perspective changes with time and, obviously, depends on the eyes you look through.

Existing potential

For instance, let's revisit a part of your daily life, the kitchen, where food preparation and consumption occur. In this setting, some leftovers, inedible and discarded food waste gets produced inevitably. These wastes are biodegradable in nature. Humans are naturally talented in outsourcing tasks; today, the mission to recover energy from biowaste is passed on to microorganisms, specifically bacteria, only the good ones though. In a process called Anaerobic Digestion (AD) within an oxygen-free environment, similar to our stomach, the bacteria feast on the bio-waste (including food waste and many others), proliferate and produce methane, a biogas that can be used for powering stoves to cook your meal, and burned in power plants to produce energy in forms of electricity, fuel and heat. It is worth noting that AD is not limited to food waste; it can handle most decomposable materials ranging from animal waste to agriculture residue. However, the biodegradable ingredients are only partially consumed by the bacterial cluster feeding on them, leaving some waste and residues behind. This mixture is called digestate with batter-like consistency and is viewed as waste or by-product, depending on perspective, again.

Solution to sustainability

This digestate is my treasure and is a gold mine in disguise for plant essential minerals, nutrients and organic matter. My research focuses on extracting, processing, and packaging this value, in this case, the soil and crop critical components, into bio-fertilisers and organic nutrient cocktails (aka bio-stimulants) for enhanced plant growth and arable soil health. All this process aims at reshaping the aforementioned linear economy into a closed-loop model called the circular economy. Sustainability, in much simpler terms, 'the back to nature concept' is the underlying principle of the circular economy. This research emphasises in developing a link from energy-recovered organic waste residues (digestate) to fertilising products that aid in growing plants and agricultural produce sustainability and efficiently. All while reducing dependency on agrochemical and mineral fertilisers thus minimising agri-related greenhouse gas emissions. Finally, this agricultural produce gets consumed and residues enter back into the loop as biowaste; thus, connecting all links of the chain for the closed circular model in climate resilient sustainable agricultural bioeconomy *(Figure 2)*.

Figure 2: The proposed closed loop model for sustainable agriculture.

INVESTIGATION OF 'CHLORINE-FREE' CLEANING PRODUCTS AS A SOURCE OF ALTERNATIVE RESIDUES

Written by: **Daniela López Henao, MSc by research candidate**
Department of Physical Sciences

Ireland is a developing nation that relies heavily on agriculture, and the manufacturing of dairy products is a significant component of this industry[1]. People in this nation and throughout Europe consume milk and goods derived from it on a daily basis[2]. According to the Irish food authority Board Bia, 8.75 billion liters of milk were produced by Irish farms in 2021, a rise of more than 2 billion liters since 2015[3].

One of the most prominent fears in Europe around food safety is the presence of hazardous by-products in food. This situation ended in creating the Rapid Alert protocol to inform all European countries about the risk in food[4,5]. One of the main problems with chlorine-based detergents is their reactivity with milk[6]. This reaction can create certain by-products. The main example is the production of Trihalomethanes (THM)[7]. The presence of THM in food can cause diverse health problems, so it is important to change the presence of this by-product[6]. That is the reason why changing the disinfection process in the dairy industry is so important *(Figure 1)*.

Figure 1: Detergent's importance in the dairy industry.

The chlorine-free detergents, in this context, are becoming a great opportunity with good performance in disinfection activity and can also be used effectively in lower temperatures.

This means less cost in the disinfection process and erases the presence of THM in food[8].

However, how can we be so certain of these new chlorine-free detergents safety? And how can we assess whether these harmful byproducts are present? These inquiries form the basis of the ongoing study.

Figure 2: Raman microscopy and SERS samples holders.

Raman Spectroscopy is a non-invasive, non- contact and non-destructive optical technique *(Figure 2)*. A laser hits the sample and 1 in a million of that light produces what is called as a Raman signal[9]. Raman signal contains scattered light that is different in energy to the laser, which contains information on the sample. This technique has also been used in milk component characterisation, like fats and proteins, in recent years[10] and has also helped detect detergent by-product formation[11].

But Raman Spectroscopy by itself has low efficiency for that purpose. Hence, we use Surface-Enhanced Raman Spectroscopy (SERS). SERS (Figure 2) is a technique that helps to increase the number of molecules with similar energy in the same area*12*. This is useful for the detection of possible by- products coming from chlorine-free detergents, like glycerol and others.

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AN INVESTIGATION INTO THE PROVISION OF TRAUMA AWARENESS TRAINING IN THE IRISH EARLY CHILDHOOD EDUCATION AND CARE (ECEC) PROFESSION

Written by: **Catherine Sheehan, PhD candidate**
Department of Sport, Leisure and Childhood Studies

Did you hear about the trauma awareness training for Early Childhood Education & Care (ECEC) practitioners in Ireland? No? That is because there is little evidence to support that trauma-related education is currently offered to those working in the ECEC profession. Yes, it is a problem, and here’s why:

You open the door; the pungent smell of cigarettes and a foul smell of damp invades your nose. You readjust your scarf for warmth because the heating bill hasn’t been paid. What’s that noise? Drip, drip, drip. You quickly turn to observe a leak, a constant elimination of stagnant water from the upstairs bathroom that has matured over several months. But there’s another noise catching your attention. You try to block it out but it’s too intense, too unsettling. The chaotic yells of two adults entangled in an argument, yielding more unwanted emotions of unsafety, distress, and worry. More volatile exchanges that can be added to the *household dysfunction* jar, as the *neglect* one is too full. You can’t help but feel miles away from any prospect of love, laughter, and nourishment, the distance widening with every adverse uncovering.

As you meander through the hall, you make a stark discovery. You can’t believe what you find in the corner of the room amidst the irrefutable disharmony. A soft, fragile little hand reaches out to you, seeking connection and safety. You can’t bear to think about the host of implications that these adverse childhood experiences can cause across the lifespan, precisely the emotional dysregulation (Adkins et al., 2020) and difficulty building relationships (Nicholson et al., 2019). Your heart sinks as you reflect on all the children in your preschool who have been touched by trauma and adversity, signs and symptoms unbeknownst to you. But knowing the appropriate strategies and pathways to healing fail you, you weren’t trained for this, in fact ≥ 60% of ECEC practitioners have no trauma-related education (Butler, 2020). And to your dismay, you learn that trauma is not always so forthcoming, sometimes it resides in the most unsuspecting of homes, or can disguise itself behind a pristine uniform, a raised hand that knows the answer, or even the team captain. Essentially, a discourse that is often well acquainted with people from every socio-economic background; a rootless trajectory that does not discriminate.

This catalyses you to embark on a mixed methods research project. Following a two-phase methodological approach, you aim to develop and implement a trauma awareness training programme for the sea of dedicated ECEC practitioners who have voiced their readiness to receive targeted and evidence-based education (Nicholson et al., 2019). Here, the intervention can be made widespread; establishing key relationships and utilising the unique role of ECEC practitioners to be the buffer, underpinning why trauma awareness training is so important. Strides to transform the current training landscape for the ECEC profession has the potential to re-write the Irish narrative, and to reflect the global efforts of international countries (Brunzell et al., 2019; Morgan et al., 2015; Shamblin et al., 2016), and *that* is why this work is so important.

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THE RIGHT TIME

Written by: **Caitlin Kelly, PhD candidate**
Cork School of Music

THIS DOCUMENT USES THIS FONT TO MAKE IT MORE ACCESSIBLE FOR DYSLEXIC PEOPLE, AS WELL AS A COLOUR SCHEME TO MAKE IT MORE READABLE FOR COLOUR BLIND PEOPLE. THE DOCUMENT HAS ALSO BEEN CHECKED FOR SUITABILITY WITH A SCREEN READER

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CAITLIN KELLY

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Over the last year, I've visited 11 different cultural heritage sites as a part of my research into Accessibility and Cultural Heritage. These visits were to investigate just how accessible these sites were or, as it frequently turned out, were not. The sites that were chosen were a mix of some of the most popular sites that Ireland has on offer, as well as some of our "hidden gems"[1] that have a very small tourist footprint, but are still important to the communities in which they reside. I looked at a variety of different accessibility features, both inside and outside the site. One of the elements that I surveyed during the accessibility studies was multimedia presentations – this included things like short films, digital presentations, interactive touchscreens, to give a few examples.

The site that had the most accessibility measures implemented (including braille signs, something not seen in any of the other sites) had a short film featured. The film had several different languages available to be played in a small cinema that was wheelchair accessible. However, one thing that was missing from this presentation was closed captions or subtitling for people who were deaf or hard of hearing. Given how exceptional this site had been in implementing other accessibility measures, I was curious as to why.

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When discussing it with a member of staff, they were quick to acknowledge the shortcoming. The reasoning they gave it was because the film was around 8 years old, too old to be adding subtitles now, as they "would be updating it soon."

This statement would prove to be particularly interesting.

The next site, while quite impressive in scope and the number of multimedia elements, was significantly less accessible than the previous site. However, the new visitor centre attached to the site showed a lot of promise – it had tactile elements, and while it didn't have braille, the writing on the signs was raised and had a sans serif font. (For reference, sans serif looks like this, while serif fonts look like this). Again, this site had a short film. And again, there were no subtitles, or closed captions.

Given that this centre was much newer, I was intrigued. So once again, the topic was discussed with a member of staff, as to why. The response? The film is too new, it will be implemented eventually.

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And so, we have reached the crux of the problem. If the old film was too old, and the new film was too new, when is the right time to make something accessible? The obvious answer is that the best time to include people is from the beginning. But what about the second best? Right now. Every extra minute that things like this are left to slide between the cracks is an extra minute of exclusion. In the words of G. F. Williams, disabled people travelling to these places "will not only be left out of the fun but will also be left out of the conversation afterwards."[2]

Word count without bibliography: 500

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THE FUTURE IS NOW

The importance of investing in young adult health

Written by: **Danielle Kenndy, MA by research candidate**
Department of Management & Enterprise

The future is now, what does that mean? The phrase is akin to what one may hear roll off the tongue of whatever 'super genius' tech CEO is trendy at any given time. Today however, I implore you to forget about cars, computers, or phones, but instead to consider what this phrase means with regard to the health of our youth population.

Most people like to think that they are invincible when they are young, that what they do in the present will have no consequences. The truth of the matter is however, that every action has a consequence. To think otherwise would be naïve, like toppling the first domino and being surprised when the rest come tumbling down as a result. What else did you think was going to happen? Similar to this run of dominoes, the actions we take in our youth will inevitably catch up with us. If each piece aligns accordingly, eventually the final domino will fall. Now imagine for a moment what would happen if just one domino is removed from the run. Imagine the silence hitting your ear as the dominoes cease falling. Just like that, the removal of one small piece from the run ensures the final domino stands tall.

Now let's think of this run of dominoes in the context of young adult health, with each piece representing a risky behaviour such as smoking or drinking.

To some these behaviours may seem fun, cool, or even 'harmless' at first, but they are associated with a multitude of negative outcomes for one's short and long term health. Time and time again parents around the world have attempted to warn their children about the dangers of partaking in these risky behaviours, receiving only snide remarks and slammed doors in return. Unfortunately, listening to one's parents is a trait not commonly found in young people, no matter who's right or wrong.

With health there comes a point where the damage is done, all dominoes have toppled, the negative health effects of these behaviours have caused structural issues and suddenly the house is falling. To prevent the fall of the last domino, the point of no return, we must prioritise the health of our youth population. To do so we must invest in our health systems and in our people. No longer can we just listen to the evidence, we must act, we must intervene. We must remove a domino from the run and stop the pieces falling. If young people fall, we all fall as they are the future. Can you imagine a world without them?

THE CONNECTED MINDSET OF A FACILITATOR OF INNOVATION

Written by: **Monika Dukarska, PhD candidate**
Department of Social Sciences

Being a business owner is a complex undertaking. Besides managing the day-to-day operations of a business, the entrepreneurs are required to safeguard the future, by innovating and behaving entrepreneurially. However, this is easier said than done.

Innovation and entrepreneurship are concepts which in the past were perceived to be linear and fixed in terms of phases and approaches used. Now, they are defined as multidimensional, flexible, dynamic and involve several other players in a wider innovation and organisational network. Similarly, organisations were perceived as stand-alone entities and were mainly concerned with their own operations in order to survive. Now however, they need to account for other, often unforeseen and unpredictable developments, activities and players in their internal and external environments. These environmental shifts pose greater threats to smaller players in industries, due to innovation barriers that these organisations experience, e.g., location, lack of finance and resources, size, availability of talent, and time to name a few. These organisations however are hungry to innovate, and can be flexible and resourceful to respond to these changes. But why more often than not, these business struggle to avail of innovation opportunities?

Business innovation can be like playing a football game. You play on a football field, which represents the wider organisational environment and your network. The field is divided into two halves, one half represents your internal environment - your organisation - such as staff, partners, stakeholders etc. The other half represents the external environment, namely your competitors and other players, who your organisation can potentially network with, to achieve you organisational and innovation objectives.

Networking in this case would include 'ball passes', which are received and converted into scoring opportunities by your organisation. Thus, for the business to survive, it needs other players on the field and it requires creativity and application of an entrepreneurial behaviour to score – meaning to bring a product, service or an idea to market to create value for a potential customer. Therefore, this clearly illustrates that innovating relies on various relationships and actors in the wider organisational network, and these relationships are like ball passes between players – some are frequent and long (-lasting), others are short (-lived) and not always fruitful, however necessary to partake in the game and to be competitive.

An agent, who can support innovation efforts and guide/optimise the networking opportunities for an organisation is a facilitator. This facilitator has an ability to successfully connect the three constructs, namely innovation, entrepreneurship and networks, to support innovation activities. An innovation facilitator is someone who has knowledge about and experience with innovation. It is a person who educates, advocates, and advises others within an organisation on innovation, raises the organization's awareness of the importance of same by providing a set of tools, and developing training activities and a person who engages with various stakeholders throughout the innovation process. In football terms, it is the Manager who equips the players with the necessary tools, resources and knowhow and he can be the difference between winning or losing.

CROSS-LAMINATED TIMBER

Sustainability in buildings

Written by: **Muhammad Yasir, MEng by research candidate**
Department of Civil, Structural and Environmental Engineering

Housing and buildings are an integral part of our daily lives. Every building is made of construction materials with different natures and origins. The main source of the material used in the building construction defined how sustainable the building is throughout its life cycle.

This research focuses on the development of new wood-based solutions named cross-laminated timber (CLT) for the construction of buildings. Cross-laminated timber (CLT) possesses enhanced structural capabilities and is considered a sustainable structural product that can reduce emissions of carbon compared to traditional building materials, including steel and concrete. The current building sector is one of the major sources of producing greenhouse gases and carbon dioxide (CO_2) emissions. Therefore, this sector possesses a significant potential to mitigate climate change and reduce CO_2 emissions. The main aim of this research is to study the sustainability performance of cross-laminated timber (CLT) as a construction material. However, the performance of timber-made structures such as CLT under fire situations is a great concern for stakeholders including the owners, designers, and engineers due to its combustible nature.

This research is based on the testing of CLT panels when exposed to fire in the furnace at Munster Technological University (MTU), Cork. Different types and combinations of fire protection systems were used to improve the performance of CLT panels under fire. The delay in charring and temperature distribution at different depths of the CLT panels were recorded and comparisons were made between different protective systems. The results show that the charring of the CLT wall panel can be delayed significantly by using the fire protection system studied in this research.

The presented research is a joint project between the University of Galway and Munster Technological University which is funded by the Department of Agriculture, Food and the Marine. The project aims to enhance the use of Irish timber in buildings that will be optimized for fire and its integrity. The outcomes of the research will contribute to future sustainable construction and will allow the use of the most efficient and fire-resisting building material.

A TEAM PLAY OF WIRELESS DEVICES

Communication in industries

Written by: **Tabinda Ashraf, PhD candidate**
Department of Computer Science

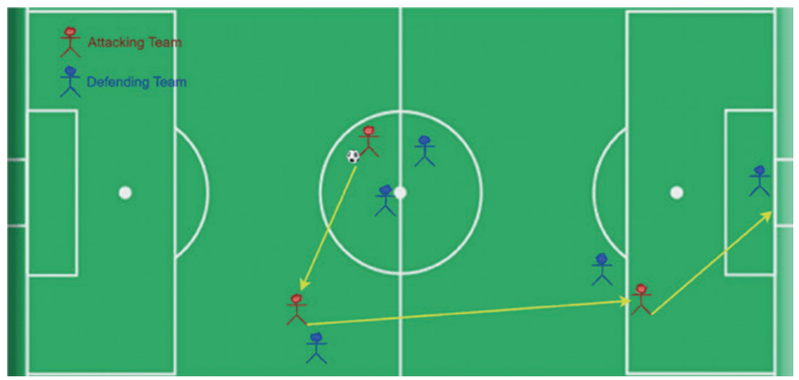
Communication is the key for everything, be it work, life or relationship, and it must be effective and clear to achieve its specific goals. In every walk of life tips and tricks are adopted, and strategies are developed to make this work. Wireless communication in Industrial networks is no different where many devices work together as a system to make a final product. These devices are most of the time sending and receiving data to each other. It is crucial that the messages reach well in time and are correct when received. This is where the concept of cooperative communication plays its role, where devices work together in a network to ensure successful communication.

This is like the teamwork in a football game where the players of a team assist each other to score a goal, as can be seen in the picture. Let us closely observe a goal scoring scenario where the striker has the ball and is trying to find a way to shoot towards the goal, but multiple defenders of the opponent team are not giving him space to shoot precisely with power. Now, either the striker points out one of his teammates with a clear view of goal or a teammate gives a hand or an eye gesture.

The striker passes the ball to that teammate instead of shooting it directly towards the goal. The teammate, who has a clear opportunity, glides the ball into the back of net to score a goal. The football field is like an industrial floor where multiple devices are operating to achieve a particular task. The striker is the source of information, the goal net is the destination, and the teammate is serving as a relay. Since the goal *(destination)* was not in the range of striker *(source)*, a teammate *(relay)* was used to successfully send the ball *(message)* to the goal.

In an industrial environment, there are multiple obstructions in the form of heavy machinery and moving metallic parts that make the communication very difficult. It becomes even more challenging if the devices are located in hard-to-reach areas. In such cases, more than one helping devices should come into play. This is like playing against an opponent team that is more defensive, multiple teammates *(relays)* should be used to score a goal, or to send the message successfully.

Unlike one man show, cooperative communication realizes a teamwork among various wireless devices to ensure quick and accurate relaying of messages.



CREDENTIALS ARE NOT ENOUGH

Verify people are who they truly say they are

Written by: **Andrew Kenneally, PhD candidate**
Department of Computer Science

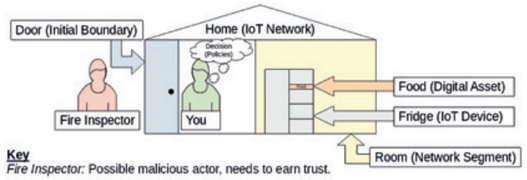
Suppose for a second that a stranger calls to your home and asks to check each room in your house for “fire hazards”. You must now decide whether to let them in, or tell them to check for fire hazards somewhere else *(preferably nothing rude, let’s not go that far)*. To begin with, you wouldn’t know who the person actually is. So, you might ask for a name, maybe even what organisation they work for. Furthermore, you would account for vaguely related factors such as the time of day, what they have on their person, if this had been planned and arranged by you beforehand... The decision making process here requires a certain level of critical thinking and all contextually sensitive information must be taken into account in order to make a safe and secure decision.

How about instead of taking any of that into account, you let anyone with the keys for the house in. What if they’re stolen keys? Forged? What if an old house-mate who never did the dishes got a little disgruntled from all the times you complained to the landlord and then gave their old keys to the “fire hazard inspector” thereby allowing them access? This approach would be extremely insecure.

If they enter your home, you’re still allowed to defend yourself and your prized possessions but it’s too late at that stage. If the person is indeed a malicious actor and they’ve breached that initial perimeter, they most likely would have already caused some kind of damage whether it be psychological, physical or financial.

Now, if they’ve entered your home after you followed the correct decision making process. Would you allow them free reign to do whatever they want? You certainly wouldn’t. If the fire hazard inspector wants to raid your fridge, they should at least ask for permission first. Otherwise, it would be considered a severe breach of trust and you can kick them out.

House Analogy for IoT Networks



Key
Fire Inspector: Possible malicious actor, needs to earn trust.

You: Decide whether to trust the fire inspector and what they are allowed to do. This decision can be defined by policies.

Initial Boundary: Perimeter defense on a network, typically a firewall.

IoT Network: Generally consists of a collection of network segments sometimes just one.

Digital Asset: A virtual object that you wish to protect.

IoT Device: A piece of equipment, that may contain digital assets.

Network Segment: Contains a group of associated IoT devices in an IoT Network.

What’s important is that from the very beginning you place zero trust in the individual. Trust is built up through the validation and assessment of the scenario and the various pieces of information that are known of the individual. Nothing is left unconsidered. Currently, Internet of Things (IoT) devices are not sophisticated enough to make these kinds of “educated” decisions on matters related to security. My research will look at ways to enable the kinds of decision making needed on a given IoT network both at its “front door” and in its “home”. This decision making process will reference “policies” set in advance of the decisions, these policies act as a list of validation points or “questions”. Thus...

I am researching a way to implement a policy decision point mechanism for zero trust IoT networks.

SECURE PROVISION OF DECENTRALIZED ORACLE NETWORKS (DONS) FOR DAML TECHNOLOGY

Written by: **Iqra Mustafa, PhD candidate**
Department of Computer Science

Decentralized oracle networks (DONs), also known as blockchain middleware, are crucial elements of a blockchain ecosystem as they extend the functionality of blockchains by connecting smart contracts to real-world data, events, off-chain computations, etc., in a tamper-resistant and reliable manner. Without oracles, smart contracts would only be able to access the transactions recorded on their own networks, making them somewhat ineffective. DONs not only operate as a data source themselves but also as a layer that employs different oracle decision models to query, examine, verify, and validate resources from external services for use on the blockchain.

DONs compile multiple external data streams using a variety of methods, such as APIs, SDKs, tamper proof data, IoT sensor data, big data, or others, and provide these as a signed message on the blockchain. The external data can be of any type, including weather conditions, successful payments, and price fluctuations. To request data from the outside world, a smart contract needs to be triggered, and network resources are spent. This results in network transaction charges, such as “gas,” in Ethereum.

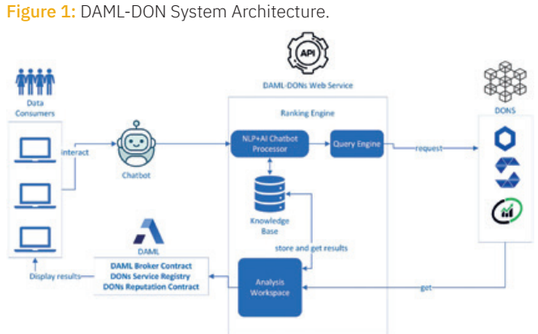
However, the provision of smart contract data feeds is impacted by the quality of the data source because when a smart contract relies on a new trusted intermediary, the oracle in this case, it would be violating the security and reduced-trust model of blockchain applications. This may result in malicious smart contracts, which provide criminals the opportunity to maximize their gains through engaging in illegal activity by corrupting the contract parameters and seriously undermine the security of cyberspace.

Problem Statement:
Ensuring the reliability of data sources has become priority for oracle providers in recent years, leading to the development of numerous types of reliable decentralized oracles, including Provable, Witnet, Band protocol, and Chainlink etc. These external oracles are supported by most smart contract development platforms i.e., Ethereum, Fabric. But Digital Asset Modelling Language (DAML) which is platform independent technology for smart contract development cannot leverage from these external oracles because calling external APIs in response to contract execution is not supported, which limits the applicability of DAML-based contracts. Additionally, no trust management mechanism is available in DAML for secure and reliable communication between DAML users and DONs.

Contributions:
Hence the specific contributions this study makes are outlined below:

- Extending DAML to support DONs via secure web service. This service connects DONs and DAML clients for real-time trading tailored to their requirements via DAML Broker Contract.
- The proposed system is equipped with ranking engine that comprised of service registry (store logs) and client reputation component. These are responsible for evaluating DONs reputation based on peer experience and aid DAML Clients’ to call reliable oracle providers by providing oracle addresses with ranks in a secure manner. Prior to their encounter, it saves clients time and cost.
- A chatbot to aid users in intelligently submitting data request forms by reducing errors. Additionally, displayed the chosen data provider’s reputation analytics, see Figure 1.

Figure 1: DAML-DON System Architecture.



TOWARDS A FASTER AND EFFICIENT WORLD

Implementing Software-defined networking (SDN)

Written by: **Saujanya Mathanda Sanjaya, PhD Candidate**
Department of Computer Science

Software-defined networking or SDN, is an innovative technology that helps in designing and managing networks virtually. SDNs use software to communicate with underlying hardware and direct traffic on a network.

Let us take a drive in your car while I explain what SDN is. Imagine starting from your driveway having no phone, GPS, internet and electricity during this drive. You drive towards the city, taking the usual route. The traffic is unusually high today, and with the absence of electricity, the traffic lights have stopped working. You see a traffic jam ahead and it is too late to turn your car around as an ambulance, a fire engine and a Garda vehicle come to a stop behind you. It gets very chaotic as the emergency vehicles can only move if the traffic congestion ahead is alleviated.

Let us restart this drive, starting from your driveway. This time you have your phone, the GPS in your car works fine, and there is electricity powering the traffic lights. The traffic is unusually high on the road towards city. Your GPS warns you of the traffic and guides you through a faster route with less congestion. You notice that the traffic lights change at regular intervals, controlling the traffic and the emergency vehicles get right of way and pass ahead.

On a normal day, there is someone driving a car, and there is a GPS telling the driver when to turn. A GPS can tell many different drivers, in all their different cars, where the next turn is. The traffic lights prioritize traffic arriving in different directions. Both the GPS and the traffic lights together reduce the chaos caused due to traffic arriving in all directions and heading towards different directions. A network traffic is similar to real traffic, where information are like the vehicles traveling on the road (network). More the information in the network, more is the traffic.

The SDN works like the GPS and traffic light in a network. There is one thing to drive the information and there is another thing that gives the direction. Like emergency vehicles, there are priority information, which do not appear often, but only when something unusual has happened. This information must be given higher priority. Much like the GPS having the map of the city, the SDN has the entire network map to create the shortest and fastest path and prioritize critical messages.

What makes SDN so different from a regular network? A patient in the ambulance can lose their life if they are not taken to the hospital on time. Similarly, a critical information that does not reach its destination can cause the system to fail. SDN plays an important role in creating paths on the go and prioritizing the traffic to ensure timely delivery of information.

A WEARABLE WINDOW TO THE MIND

Demystifying Automated Psychophysiological Analysis

Written by: **Zachary Dair, PhD candidate**
Department of Computer Science

What comes to mind when you think of wearable technology? Of course, you may think of fitness tracking, monitoring your steps, heart rate, and sleep patterns. But what if wearable technology could do more than just track physical fitness? What if it could also help you understand and manage your mental well-being?

Wearable devices such as smartwatches monitor your physical condition, capturing informative data such as heart activity and skin temperature. Analysing this data enables valuable insights into your mental health, well-being, and emotions. Why is this important in a real-life environment?

Imagine you are struck by an incessant panic, with each heartbeat thundering and every thought deafening. Despite this, you sit quietly. Several minutes pass, but in that anxious state, the seconds crawl by. With a shaky glance at your wrist, mere moments until “the big one”. You have been working towards this for an eternity, and your nerves won’t submit despite your extensive preparation. The anxiety is inescapable. Unable to focus, you wish for assistance in this stressful moment.

Thankfully, with a pair of headphones and a few taps on your smartwatch, aid is there. The artificially intelligent companion chimes through the headphones, instantly analysing your heart activity, skin temperature, and breathing. An alert appears: “Detected high stress”. After a quick tap, you hear “Calming Session Started.”, followed by the soothing tones of your perfect comforting song, interspersed with words of support and motivation. Immediately you feel relief as the panic dissipates.

But this is just the beginning. The potential for wearable technology for mental health insights extends far beyond just helping you manage your mental health in real-time. It also can provide pre-emptive warnings of mental states such as depression, prolonged stress, and anxiety. It even offers an avenue for delivering emotional intelligence and awareness to artificial assistants, games, and applications, leading to more natural and personalised interactions between humans and computers.

Think about it- imagine if your smartwatch could detect signs of stress or anxiety before you even realise it and offer personalised solutions to help you cope. Imagine a virtual assistant that could understand and respond to your emotional state, providing a unique understanding of your current state and making interactions more intuitive. The possibilities are endless.

While the possibilities are exciting, there are significant challenges. For example, the data can be complex and is mainly collected in controlled environments. In addition, people have different mental health needs, emotions, and responses to stress, anxiety, and depression. Finally, complications can arise when studying mental health in real-life, everyday settings. All these challenges must be considered to ensure accurate results that can be applied to different people.

It can be challenging to step back and understand our emotions in today’s fast-paced world. However, wearable technology and automatic psychophysiological analysis provide us with the tools to do just that, in real-time, without interrupting our daily lives. This technology has the potential to greatly aid our understanding and management of mental health and well-being, leading to a happier, healthier, and more connected world.

GAN BASED ARTIFICIAL INTELLIGENCE SYSTEM FOR IMPROVING COMPUTER AIDED DIAGNOSIS IN HEALTHCARE

Written by: **Muhammad Muneeb Saad, PhD candidate**
Department of Computer Science

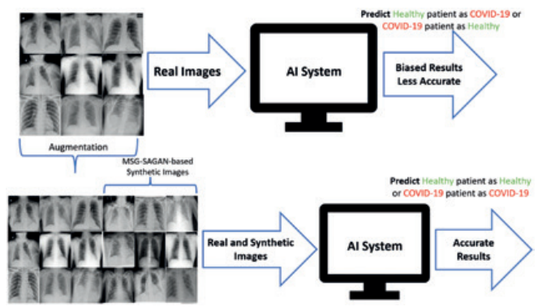
Corona Virus Disease, 2019 (COVID-19) is diagnosed using a Polymerase Chain Reaction (PCR) test, X-ray images were used when there was a shortage/ lack of access to PCR. These images are required to analyze the wide spectrum of disease more significantly. Artificial intelligence (AI) techniques have been implemented to diagnose the disease using computer-aided diagnosis. AI models help medical doctors diagnose diseases more quickly and accurately. AI models are designed with machine and deep learning techniques for automated analysis of the disease[1].

In the domain of biomedical imagery, the availability of data is an obstacle to the application of AI systems due to patients' privacy issues and the rarity of the disease. These AI systems incorporate deep learning (DL) models for automated diagnosis. DL models require large training datasets for better diagnosis, a challenging problem in the biomedical imagery domain. The prediction performance of DL models is also degraded when dealing with class-imbalanced datasets. These datasets contain image classes with different number of images. Data augmentation is one of the potential solutions to address the class imbalance as well as the data limitation challenges by adding more copies of images to the actual dataset[2].

Generative Adversarial Networks (GANs) are used to enhance the size of image datasets and balance the datasets using additional set of images. GANs generate synthetic images that are used in conjunction with real images to train DL models and improve their prediction accuracy of the disease such as COVID-19. GANs learn the distribution of real image features and generate synthetic images based on those learned image features. Sometimes, GANs face a mode collapse problem when dealing with the diversified image datasets. It generates only specific synthetic images repeatedly and misses many images with different feature distributions. This problem limits the utility of GANs for image datasets with a diverse range of features in the context of the biomedical imagery domain[3].

In this work of MSG-SAGAN[4], a self-attention layer is proposed in the multi-scale gradient GAN (MSG-GAN) for generating diversified chest X-ray images of COVID-19, as shown in Figure 1. The MSG-GAN was unable to generate the diversified synthetic COVID-19 X-ray images as dataset contains diversified images. The proposed MSG-SAGAN has successfully generated diversified COVID-19 X-ray images as compared to the actual MSG-GAN. MSG-SAGAN can focus on diversified COVID-19 X-ray image features using the self-attention layer. X-ray images are important as they contain scans of a wide spectrum of the disease with diversified features. A diverse set of GAN-based synthetic images can augment datasets and improve the automated diagnosis of AI models. MSG-SAGAN can better augment the imbalanced/limited datasets using diversified synthetic images, which helps a model diagnose the disease more accurately and efficiently.

Figure 1: A block diagram of disease diagnosis of COVID-19 X-ray images using MSG-SAGAN based diversified augmented dataset.



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School of Graduate Studies
MTU Bishopstown Campus, Cork

Tel: **021 433 5099 / 021 433 6255**
Email: **Graduate.StudiesCork@mtu.ie**

MTU.IE