

XRDS Article

Title: Benchmarking Robots in Smart Cities

Dek: We need to be able to prove that robots do their jobs reliably, and show people that this is true. Robot benchmarking competitions in smart cities showcase robots and let people see a glimpse of our future, as seen in Bologna in 2021.

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Introduction

Technology has an increasing impact on all our lives, and as the population of the world becomes more predominantly urban, it is in cities that most of us will feel this impact. Two technologies which seem destined to shape our experience are Smart Cities and Robotics. Of course, for robots to be useful we need to trust that they will do their job properly and reliably, and this requires that we should be able to test them against standards, and see their performance with our own eyes.

In this paper we explain why the SciRoc project brought robot benchmarking to Smart Cities, and how we overcame some of the difficulties of running a successful robot competition in the city of Bologna during a global pandemic. These innovations may pave the way for easier robotic benchmarking in the future.

SciRoc and the ERL. Background and Motivation

The label 'Smart Cities' is used with increasing frequency with a main focus on the use of engineering approaches within the urban environment to maximise the quality of life of the citizens. These visions present the city as an informational entity, gathering and processing data in support of decision makers and infrastructure, and offering data services to other stakeholders to enable and improve the services they offer. The city senses, processes, and acts purposefully upon receipt of environmental stimuli, as as such the Smart City itself resembles a Robot. We might expect to find some commonality between Smart Cities and Robots, additional advantages from their integration, and also find some common problems on the road to adoption.

The world's population is becoming more urban, and therefore it is likely that more and more people will live in Smart Cities and that this is where most interactions between humans and robots will take place. Because of this, it seems that any ethical challenges that arise from the marriage of Robots and Smart Cities will be particularly important for the citizens of the near future. How can robots act best to sustainably promote our happiness and prosperity?

As a result of a series of initiatives funded by the European Union's Framework 7 and Horizon 2020 programmes, the European Robotics League (ERL) has been organising competitions for robots and their human helpers throughout Europe. These competitions are based around benchmarking, and aim to provide the robots' developers with data to enable the comparison of different systems, algorithms and approaches to solving complex tasks (Lima et al. 2017). The ERL originally consisted of three challenges, which were suitable for Industrial, Service, and Emergency Robots;

with the latter challenge requiring that air, land and sea robots should work together to solve a simulated disaster. We have since renamed the Industrial challenge as 'Professional', and the Service challenge, 'Consumer', to recognise the ways in which robot technologies and projected use cases in these sectors are converging around human and robot co-working.

One feature of the competition events which comprise the ERL, and which they have in common with the majority of similar robotics demonstrations, is that they tend to happen in locations which do not readily lend themselves to public engagement. Robotics competitions are often hidden away from normal view, being removed from daily life by virtue of being co-hosted with robotics conferences or in test facilities in robotics labs (both of which necessarily limit access to the public), or by virtue of their particular requirements for accessible and safe use of outdoor environments spanning marine, land and air domains.

We know from surveys that attitudes towards robots are mixed (Eurobarometer 2012), though it is debatable if these attitudes are based on fact or Hollywood fiction. If we want to underpin public discourse with facts, and raise issues around acceptance and desirability of different use cases for robotics, we must move our demonstrations into the arena of everyday life, and therefore we are determined to bring the ERL into the light.

For these reasons, the SciRoc project built upon the ERL to include the *Robotics in Smart Cities* Challenge. In this, teams and their robots who have built competences in the other ERL Challenges come together to tackle relatable and realistic tasks in the Smart City environment. It is mandatory that they use the data infrastructure of the Smart City in carrying out these tasks, prototyping the sorts of interactions which will underpin future applications, and demonstrating additional value from the investment already made by the city host.

The first such Smart City Challenge took place in Milton Keynes (MK) in September 2019, the fastest growing city in the UK (in terms of jobs, people and houses). The city had recently been engaged in a large "Future City" programme, at the centre of which was the 2014-2017 MK:Smart project, led by the Open University and also including the MK City Council as a core partner. The project created a state-of-the-art data acquisition and management infrastructure (the MK Data Hub) and an Internet-of-Things network with live sensors capturing many aspects of the functionalities of the city (energy and water consumption, transport data, satellite-acquired data, social and economic datasets, and crowdsourced data from social media or specialised

applications).

After the success of the event in Milton Keynes, the stage was set for our second Smart City Event. We received a number of applications from cities that were interested in hosting and running this event, and from these expressions of interest chose the city of Bologna, Italy, as the winning location.

The Bologna Event : why Bologna wanted it, the challenge of COVID

[SciRoc 2021](#) was held in [Bologna](#) from September 6th to 10th (see the [event's highlights video](#)), in the beautiful venue of [Palazzo Re Enzo](#) (provided by the Municipality of Bologna), located in the heart of the medieval centre of the city. The palace was built in the mid 13th century and was the residence-prison of [King Enzo of Sardinia](#) (son of Frederick II), who was captured during the Battle of Fossalta, until his death.



Image 1: Palazzo Re Enzo, Bologna, Italy

Bologna has an established reputation of being an inclusive city, open to civic engagement and creative contributions. According to this tradition, it interprets the *Smart City* concept as an opportunity to improve services that guarantee fundamental

rights to the community, such as sociality, education, development and health. In line with this perspective, the theme of SciRoc 2021 was *Smart Inclusion*, hence potentially involving diverse areas of intervention such as integration, sustainable mobility, shared cultural heritage, local business and public services, safe and sustainable neighborhoods, health and welfare. The main message directed to Bologna's citizens and the extended general public was that smart cities can be designed to improve inclusion by having robots that can help us and co-live with us in many different places and social situations. As in previous editions SciRoc 2021 was structured in terms of five *episodes*, each representing a scientific challenge for the competing teams and relevant for the theme (cf. Section "Benchmarking: How we dealt with the challenge").

SciRoc 2021 collected twentyone expressions of interest, and fifteen teams (from Asia, Europe and UK) finally registered and participated in the competition, six of which from remote. About seven hundred visitors over three days attended the event.



Image 2: Episode 01, SciRoc 2021.

The success of this event was a significant achievement of the organising team (the SciRoc consortium and the Bologna partnership), considering the unprecedented and unpredictable situation that they faced when they started working on its organisation, due to the COVID pandemic.

It was autumn 2019 and the [Alma Mater Studiorum - University of Bologna](#) (UniBo), the

[Foundation for Urban Innovation](#) (FIU) and the [Alma Mater Foundation](#) (FAM) teamed up to build a proposal for hosting the second edition of the ERL Smart City Robotic Challenge (SciRoc). The city of Bologna (along with Emilia Romagna) is recognised as a research and innovation hub for supercomputers, big data, artificial intelligence and automation. Moreover, in 2012 Bologna launched the *Bologna Smart City* project with a Memorandum of Understanding between the [Municipality of Bologna](#), the Alma Mater Studiorum - University of Bologna and [Aster](#). The project aims at leveraging cutting edge technologies to address the community and citizens' needs, and to improve their quality of life. Therefore, hosting SciRoc 2021 offered a unique opportunity for the city to make a strong statement in the Smart City domain and to foster a closer interaction on this topic between academia, industry, public administrations, and citizens. This is why the Municipality of Bologna and other local organisations early expressed their support to the idea of hosting the event.

The Bologna's bid was successful and the hosting team was enthusiastic and ready to start working on preparing the event, which was planned for early September 2021, when the COVID pandemic entered the scene. The team received the good news in February 2020 and in early March Italy had its first lockdown. Suddenly, everything became uncertain: whether it would be possible to run a public physical event, whether traveling would be allowed across different countries, what kind of restrictions and safety measures would we have had to put in place. The most critical issue was that all the main organisation entities and potential partners now felt uncomfortable in committing for such an event and everyone, understandably, would not consider the organisation of SciRoc a priority in their plans. This caused significant difficulties to the organising team: without confirmed sponsors the budget was too uncertain forcing them to be almost idle for several months. The team had moderate confidence of the event's confirmation only in late spring 2021: it was too late for some sponsors to join, most of the concrete organisation happened in a few months, therefore certain things could not be done anymore: arranging and selling booths, organising co-located workshops, inviting speakers, etc. Therefore, the team had to develop a plan to mitigate risks related to possible COVID restrictions and low budget availability: to reduce costs and to simplify the logistics, the competition would run in one place (the original plan was to run a diffuse event in multiple locations). SciRoc 2021 had to be a hybrid event and the challenge was to keep its relevance for the hosting city, Bologna in this case. The focus shifted then in securing funds for the local administration, the technical support and for live-streaming the event. Only one co-located event was planned, a debate between citizens and researchers in robotics and AI, from industry and academia. UniBo issued a recruiting campaign for volunteers for addressing visitors and for providing users to the episodes. More than twenty junior researchers applied to volunteer and serve for the

event. A most critical and challenging issue was to study a solution to allow the competing teams to participate remotely, by running their software in robots that would be physically performing in Bologna. Both actions (streaming and remote participation) revealed good opportunities: to innovate robotic competitions and to achieve broader outreaching and dissemination.

In summary, the pandemics significantly affected the organisation of SciRoc 2021, especially because most of the concrete organisation happened in a few months, therefore certain things could not be done anymore: arranging and selling booths, organising co-located workshops, inviting speakers, etc. It is clear that we could not express and benefit from its full potential. Nevertheless, the event was successful because it pushed the state of the art in robotics and offered the chance to learn many lessons for further improving future editions.

Benchmarking : How we dealt with the challenge

The second SciRoc event was arranged according to the structure adopted for the first one, namely we created 5 challenges that we named *episodes* to view them as a story for the smart city. Teams can enter one or more episodes, but each of them is scored independently of the others. The theme chosen by the host for SciRoc2 was *Smart Inclusion* and we tried to develop the episodes around it. It should be pointed out that we also had to accommodate other requirements, such as keeping some continuity with respect to the previous challenge to avoid losing teams and feasibility (we could not find a feasible arrangement for the UAVs). For each of the 5 episodes below we provide a short description (the complete specification can be found in the [rulebooks](#) available on the SciRoc website).

(E01) [Coffee Shop](#)

In this episode the robot assisted the staff of a coffee shop to take care of their customers. This episode has been proposed in *two modalities*: a simulated mode with the Gazebo simulator or with actual robots. Moreover, the teams have been allowed to participate in the competition both remotely and onsite. A TIAGO robot (PAL Robotics) was available onsite to run the code provided by remote participants.

(E02) [Sign language generation / interpretation](#)

In this episode, specifically designed to address the theme of inclusion and developed with an extraordinary contribution by the Italian deaf community, we had: sign language execution (generation) and sign language recognition (interpretation). In order to

accommodate the limitation of the one arm TIAGO robot used in the competition a much simplified subset of the language was designed.



Image 3: Episode 02, SciRoc 2021.

(E03) [Shopping Cart](#)

E03 was the result of a collaboration between European projects SciRoc and Eurobench (<https://eurobench2020.eu/>), more precisely a version of Eurobench's BEAST (*Benchmark-Enabling Active Shopping Trolley*) benchmark for mobile robots, which aims at testing the performance of a robot pushing a shopping cart.



Image 4: Team Hybots - Episode 03, SciRoc 2021.

(E04) [Delivery of emergency medicines](#)

In this episode a medicine is delivered to a person (e.g. to deal with quarantine-related issues). The robot task requires to move autonomously to the location, where the medicine should be delivered. Due to the constraint of indoor operation, the episode has been implemented as a navigation in a labirynt.

(E05) [Shopping pick & pack](#)

This episode addresses the problem of picking products from a storage container and placing them on a designated shelf. The main functionality tested in this episode is *mobile manipulation* using an autonomous robot. The episode has been developed in collaboration with OCADO.

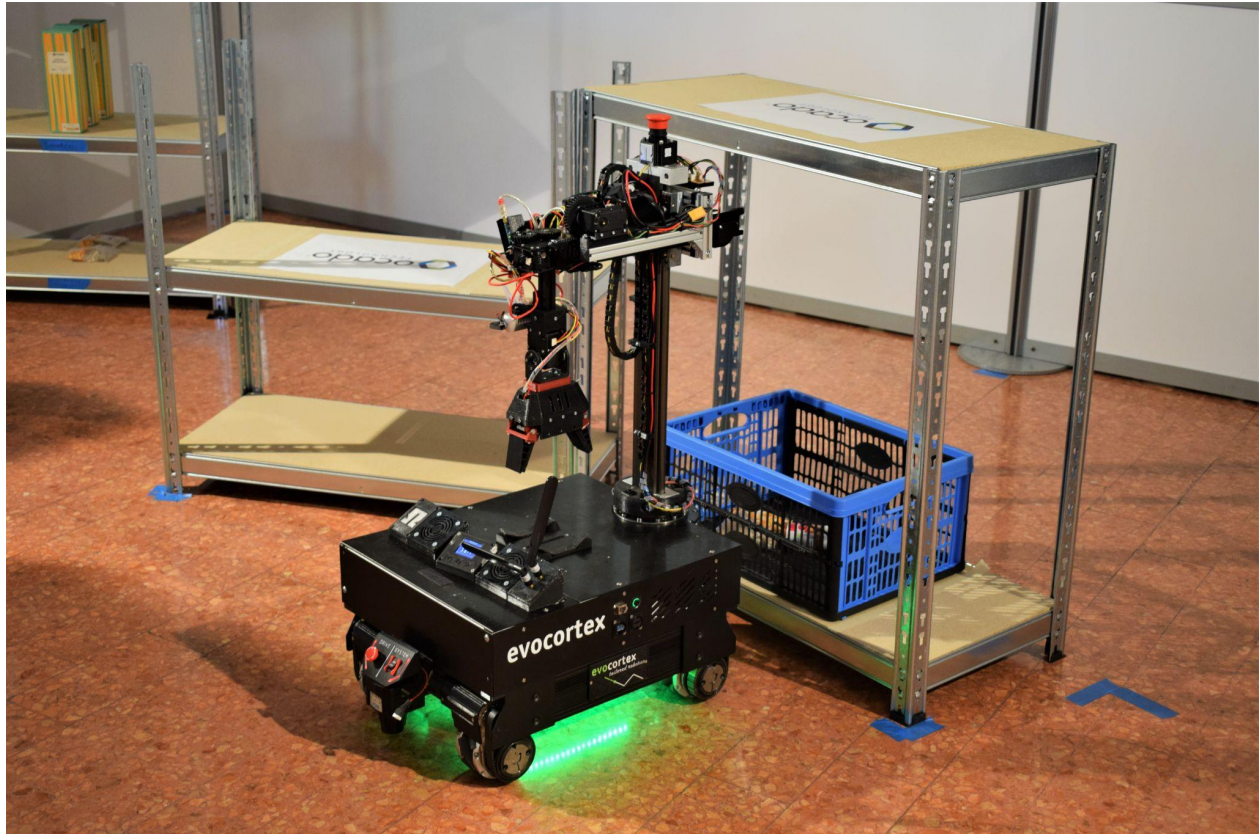


Image 5: The Robot of Team AutonOHM competing in Episode 05, SciRoc 2021.

The competition had a total of 13 teams, 6 of them attending in person, which was a great success given the uncertainties related to the COVID pandemic that affected not only the event but also the team's intention to participate. A report with all the results is available on the SciRoc website.

While the team performances suffered from the difficulties faced in the preparation phase and the technical achievements were not outstanding, the implementation of the competition addressed the challenges arising from the pandemic with innovative technical solutions in terms of the set-up of the competition. Specifically, the SciRoc project developed and implemented several new concepts: introduction of simulation environment for a service robots scenario (E01); remote participation on a physical robot made available on site thanks to a successful collaboration with PAL Robotics (E01 and E02); introduction of a novel challenge related to the sign language that had an outstanding success within the deaf community, which was involved from the design of the challenge to its implementation and, currently on the take up of the experience (E02); synergy with the H2020 Eurobench project aiming at implementing benchmarks for robots (E03); design of a new challenge for emergency robots (E04); distributed execution of the competition with both on site and remote participants performing the

tests at their own labs (E05).

Bologna Success

In addition to the innovative technical solutions outlined in the previous section, the second SciRoc challenge has been a key milestone towards the establishment of a self supported robotic competition at the EU level. In fact, for the first time, the competition was organised by a host city, which provided all resources (human and financial) to run the event, with only the exception of the technical and scientific support of the SciRoc Consortium in setting up and running the five episodes. This is an unprecedented achievement, which led to a very successful event, despite the difficulties brought about by the COVID-19 pandemic.

It is important to highlight the extraordinary impact the competition had towards the general public, given its wonderful location at the heart of one of the most beautiful Italian cities. Moreover, the second SciRoc challenge turned out to be both the first in person event organised in Bologna and also the first robotic competition to take place since the beginning of the pandemic. Attracting crowds of around 700 over the three day event and 13 international teams, consequently, it was perceived by participants and visitors as a successful step towards the restart after the pandemic.

In addition to those that joined us in Bologna, the entire event was live streamed online for audiences around the world to see, and is still available via the SciRoc website and YouTube channels. The success of this live stream was crucial in allowing our remote teams to compete and be part of the competition.

The implementation of the competition had to face significant challenges due to the uncertainty caused by COVID. These challenges were addressed with cutting-edge technical solutions in terms of the arrangements of the competition, as well as with a great effort by all the organisers, local supporters and sponsors.

Conclusions

In order to gain the benefits of robotic technologies operating in human spaces, we need to trust that robots will do their intended job. This trust has many elements (Winfield and Jirotko 2018) ; robots need to be reliable and successful to be useful, and if problems occur there needs to be a way of proving why they happened in order to work out how to avoid them in future. Benchmarking and testing is one of the ways that we prove robots can be trusted to do their job, and will become increasingly important as robot makers

commercialize their products. Trust will arise when people see robot capabilities, and know that there is a reliable ecosystem of testing and regulation surrounding their deployment and use.

In this way, the SciRoc project takes us nearer to the successful operation of robots in Europe. Citizens see robots performing relatable and realistic tasks in public spaces, and may even interact with them as part of the test process. The new ways of benchmarking we pioneered in Bologna point the way to easier access to robot benchmarking and testing in the future, where remote companies book time to test their robots in standardized and repeatable 'living labs'.

Although the current SciRoc project will finish in 2022, we are working to continue the ERL and the Smart City Events after the project's close. Our hope and ambition is that Smart City Events will continue, and the success of the Bologna event where a city partner was selected after a competitive tender process shows that, despite the difficulties caused by a global pandemic, there is good reason to trust we can continue to organize and run Smart City Robot Events in the years to come.

If you want to make a successful robot that works in proximity to humans, you'll need to benchmark your product and show people it can be trusted. Perhaps we'll see you at one of our events?

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