

Valorisation Report: Smart Sports Exercises

Summary

The Smart Sports Exercises (SSE) consortium has a beyond state of the art solution to innovate sports training, tailored to certain volleyball training problems but with large potential for extension towards other training problems and other sports. We summarize the core of the solution in this report, and discuss a roadmap towards valorisation.

We discuss various aspects that need to be addressed in follow-up work in order to make the solution valorisable (related to technology, content, and business aspects); look at competition/related work; and discuss various aspects that may promote or inhibit any valorisation attempts. Especially enlarging the number of data analytics and the number and variety of training games is a core requirement for bringing the SSE solution forward.

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1. The SSE solution

1.1. Brief summary of the solution

The SSE solution is a flexible environment for technology enhanced training in sports halls (with IMU movement sensors worn by the athlete plus sensing and display/feedback components integrated into the pressure sensitive LED video floor) with a suite of games/exercises tailored to the possibilities of that technological setup, focused on a set of volleyball training problems and based on solid insight into pedagogical and motor learning principles. In addition, the SSE solution also comprises a (prototype) retrieval tool with which coaches and athletes can find and review video of salient situations from training or match based on automatically recognized actions of the players.

Thanks to the knowledge and insights gained in SSE regarding the larger space of possible Sports Interaction Tech, our solution also ties into already existing ideas on how the suite of games should be extended for further sports domains and training purposes.



1.2. What are the USPs of our solution?

Compared to existing state of the art systems that aim for gamification of sports exercises, our floor based solutions have the following advantages:

- Multi purpose, there is flexibility in how many purposes it can be fitted for, because it is an interactive space rather than interactive equipment for dedicated exercise. Besides the core of this solution (focused on currently worked out exercises), the system provides added value opportunities for spectators and via marketing.
- A strong robust floor so it can deal with absolutely any activity carried out on it; if the activity involves floor contact, measurement and feedback can be used; but even if no floor contact (eg gymnastics on equipment) it can respond with visuals to exercises measured through other means such as cameras and IMUs
- Extremely high quality of light output, making the floor usable in the most adverse lighting conditions (large gatherings in halls, outdoor settings)
- Floor measurement allows for responding to certain things that IMU-only or camera-only systems cannot do; but also vice versa our solution offers going beyond floor-info-only by adding additional sensors.

As shown in our reports of the user studies in the SSE project, athletes and coaches/trainers see a lot of potential in this solution, and expect they will be able to use these training systems productively in their training practice.

2. Next steps: more content, further technological development

The current games provide a nice demonstrator of what is possible with the platform and why the combination (the +) matters for what it provides (it seems to be a multiplication). However, before we can roll out the SSE solution, we still need to make some steps towards more universal usefulness.

2.1. More content beyond SSE exercises

First of all there is a need for more content. This could be focused on volleyball, on other sports, or go beyond sports (rehab or leisure).

In volleyball this concerns going further on the road to extending the current collection of games to show decisively how the SSE solution allows athletes and coaches to address the full spectrum of training through multiple suites of games. The collection of games needs to go beyond single use scenarios, offering options for athletes throughout their career / training programme, covering all the various goals on various levels that they might pursue. In our WP2 work on “suite of games for attack training” we showed how this can be achieved with a relatively controlled amount of games to be developed by taking a holistic view on training goals and formats into account while designing the games; nevertheless this still requires significant extension towards training more dimensions of volleyball skills.

Although other sports like Basketball, Handball, indoor Football, (Mixed) Netball, Korfbal etc. require new forms of sensing in order to train offense and defense strategies for such sports, simple interactive data visualizations can be repurposed to start showing (with less effort) more generic visualizations of the power of the SSE solution used at these sports; furthermore, dedicated training activities could be designed for these sports just like was done in SSE for volleyball. Another opportunity lies in games for recovery but also improvement of sporting techniques of the athletes to prevent injury.

To show the multipurpose character of the system there is a need to create visualizations beyond exercise: address sports information and advertisement perhaps linked to other data. Content to make it attractive to step on the floor should be developed and measurement of usage in relation to specific content, not only for sports but for use in general, to make the integrated solution appear more attractive to potential customers. PiVOT (a subsidiary of consortium partner LedGo) could take a central role in generating content, especially in designing the look and feel of it.

In some cases oriented at leisure activities (that may take place in same locations as some sports activities), it would be worthwhile to develop content of computer games that combine the interactive floor (and movement on it) with interaction on other screens. This would provide new types of entertainment in sports environments (cf. the SuperParks in Finland).

2.2. More detailed action/activity detection and modeling

Based on the first prototypes it is clear that data interpretation as well as the interactivity needs measurements per tile of the floor, which means recognition at least per 0,5 meter by 0,5 m but preferably adding detail and interpolation within. To make the floor more sensitive in a reliable manner more investigation in the interpretation of the sensor data is still necessary, also to move from detecting weights on the floor to reliably tracking multiple persons on the floor while keeping track of their identities. Also, balls bouncing on the floor turned out to be not trivial to recognize properly as the powerful force leads to multiple measurement instances spread around the point of one single impact.

Furthermore, in order to move to other sports like Basketball, Handball, indoor Football, (Mixed) Netball, Korfbal etc., the system needs different data measurement tools for context-specific analysis of movement, as well in order to train offense and defense strategies for such sports.

2.3. Broader context that facilitates the training games, including data experts and management.

Content alone does not yet provide a complete picture towards larger implementation.

For every customer (club) the data must be customized. The general data of usage of the floor could be more or less the same for sports where the measurement of patterns in walking and movement on the floor can be shown. However, to provide the specific exercises, sensor setup, and other specific content of relevance the client should be guided. Based on our first few interested parties (a new sport center and a renovation) it is clear that a close collaboration is needed. Especially in the start this seems important, to set the right expectations, to deal with context-specific limitations, and to provide appropriate instructions regarding possible replacements, repairs, and customer help, in combination with a customer-friendly portal.

For connecting data of the floor with other data a data expert needs to be on board. Especially for professional sports purposes it seems likely that a network of these experts will be needed. This is also needed once the system is deployed in this market to properly cover data management; if the platform provides data of plays on the floor it needs to be clear who owns the data; who has access; this also in the legal context of the GDPR. Overarching institutes could play a facilitating role in this (cf. various strategic priorities from Nevoobo include digital match forms, Eredivisie player action monitoring, and (targeting) tracking of visitors).

2.4. Other sensor hardware and interface hardware (providers) for a full setup

For a full interactive experience, cameras and other sensors (e.g., wearables) can be added from industry partners. Companies such as inmotio, dashtag, xsens might play a role in the need for hardware, also leading to partnerships that might involve our consortium the other way around. However, as indicated before, handling the data also means that there is a need for a data-oriented company that is able to connect, store, and share all data, such as Sports Data Valley.

Furthermore, the current SSE solution centers on the use of the pressure sensitive LED video floor. It was shown how this can add value to sports training. However, for some exercise forms, floor projection might not be the most effective or usable way to provide feedback to athletes. To further extend the range of exercise forms that can be covered, additional hardware could be used to deliver feedback via wearables, tactile feedback, sound, screens on the walls, etcetera. In the SSE WP2 work on a design space for Sports Interaction Technology possibilities for this are explored in depth.

2.5. Possibly lower fidelity hardware for targeting the lower end market

The hardware of the floor has been developed targeting the most high end of markets. This leads to high quality specifications of the hardware, but also to a cost of hardware that is not in reach for every customer who might be interested in this solution. It might be worthwhile to explore how the specifications of the floor can be balanced against pricing to arrive at a version of the hardware that is still of high quality but where some of the performance has been sacrificed for cost, opening up a bigger potential market. This remains to be explored.

2.6. Certification

The indicated domains of interest do require certification to use it as a floor. Knowing that one of the customers to target would be a multipurpose sports center this would require various certifications which could become a lengthy process before allowing actual implementations. The main competitor in that regard is ASB Floor which indicates they followed EN 14904 in order to pass main handball and basketball organization requirements. This means next steps have to be taken regarding stiffness (including absorption/damping), surface resistance in combination with wear, gloss, and strength [for general idea [link](#)]. ASB also indicated to pass the related DIN 18032-2, and gathered approval of squash, tennis, and badminton organizations [[link](#)].

2.7. The need to move from “showing use by experts”, to “permanent use and usability”

The practice up to now was to mainly work with system integrators and international AV rental companies, this project indicates a need to move from showing use to being used by end-users in the sports exercise settings. To improve the usability of and access to the floor, the software should be as easy as possible, which indicates a need for low key interfaces to operate it, like a few dedicated buttons with a touchscreen, a tablet, or a phone. The need for a mobile touch-based interaction becomes important especially when the content has to be changed quickly. These were also discussion point with stakeholders interested in the floor for their new multipurpose sports center, as it might require additional personnel, dealing with repairs etc. Various prototypes have shown that the integration with a touch based mobile device is feasible, however the current system setup also needs improvement up to the moment that such interaction is possible. Moreover, the software needs additional usability testing to ensure the level of usability is (improved and will be) good when new exercises are created.

2.8. The initial and follow-up domains of implementation

The initial focus of the project leading up to this platform is sports training and PE (incl secondary, vocational, and higher professional education). The customers related to sports training that are reachable with on the one hand current pricing and costs, and on the other the kind of added value provided, seems to be mainly at the professional sports level and the multi-purpose high-end sports centers. For the latter, applications in sports data analytics research can also be envisioned but funding schemes to include these will be harder. For physical education, an absolute requirement would be to have the sports hall be in use all day and evening, for PE and/or club training; this suggests a collaboration with tertiary movement related education, high schools, and sports club sharing the same facilities.

Rehab provides a potential application for the floor and a general link to the SSE solutions (also see the previous work on GREAT/Padwalk¹). However, this also requires a new look to the action/activity detection level in order to find a place in-between the competition that provides several factors more accurate sensing solutions, for instance in the form of calibrated force plates which can also be quite expensive looking at their size (e.g. \$40k, and .4 to 1.2m). Working towards a comparative product in that regard is something that did not fit the current project but if at all possible (the current generation does not yet show this possibility) , at least requires further improvements in showing a sweet spot of

¹ <https://www.youtube.com/watch?v=4Xz7nO8Mful>, as well as the accompanying studies that were run: <http://ceur-ws.org/Vol-1582/6Delden.pdf>

added value in interaction and mid-level quality of sensing (e.g. rough providing rough estimates of balance or gait).

This indicates that there will be a need to go beyond these initial customers in order to provide a feasible business plan. Besides the already indicated rehab and leisure activities, something closer to the SSE platform would be the expressive body-involved interactions of traveling dance organizations, as they are also working on a professional level where a mixture of embodied, expression, measurement, entertainment; motor learning; interaction in the space and including repetitive learning before that play key roles.

Furthermore, as was clear from the start a more international market than the Dutch indoor halls are is deemed necessary, which combined with marketing revenues do still provide a feasible avenue to pursue. The latter is also the primary next domain to investigate, although beyond our current project scope, additional demonstrators have to be built to provide future customers interested in increasing marketing revenues (related to professional indoor sports) with a clear picture of their potential impact.

2.9. Conclusion

Various steps are needed before a viable market share can be reached. The most important step is additional content spanning different exercises, sports, purposes beyond training such as rehabilitation, leisure, spectatorship, and marketing revenue. Especially the latter ones will need much more work, and in several stages, as these were not part of the project and roll out of the system does not yet cover these domains enough to provide context-appropriate demos. Furthermore, on the sensing side improved interpretation on the low-level data is needed. To work towards long term use usability, repair, and setting up will all play important roles that are not yet covered. To provide a long term integration there is also a need for longer term data expert inclusion to continuously improve and provide the right insights, and cover appropriate data management.

3. The competition

For the system combination (pressure sensitive floor, exercises, IMU-integrating action detection) there are a few directions of competitors that are relevant on the short term. In a broad sense we split these up in products that offer smart sports exercises, and interactive (LED) Floors.

Although solely tracking of players is also a growing element of the market we do not focus on the competition there in this analysis. The competition includes various very accurate camera-based systems, some even (close to) being able to track the ball.

3.1. Main competing products that offer smart sports exercises, and their revenue model (if known)

There is a very small group of products that cover both an interactive surface and already provide sports exercises. The most important of these is Lü. One of our consortium partners joined in a webinar and this showed that the system is easy to use in the way envisioned with turning it on and using a tablet interface as discussed in section 2. Pricing is much lower as the system uses interactive projections based on a camera input. One of the unique features they provide is a distributed game setup where children can compete against other groups at another location, currently seemingly mostly on a score based level.

There are various dedicated products such as smartgoals (a set of pilons tracking a ball passing through) that provide only a limited set of exercises but are extremely affordable and also used in professional settings. Another example of this is Fitlight (and similar to this LED's GO) a touch sensitive programmable LED ring that can also export the results of the exercise [\[YouTube\]](#). A few of the selling points of such a system are the pricing (around €450 for LED's GO), a dedicated-tablet interface with end-user programmable/adjustable exercises, and various showcases on how to use the system for boxing, fitness (e.g. push-ups), soccer, baseball, basketball, running, etc.

Besides these mobile products there are of course less mobile dedicated sports equipment also suitable for fitness settings regarding skiing, skating (e.g., sliding machines), squash-like sports (e.g., Richochet ball tracking [\[link\]](#)), cycling or rowing (e.g., ergometers), or running (e.g., treadmills), some of which might be useful for ball sports as well.

Playalive is oriented more towards playgrounds and offers both these interactive LEDs and interactive walls. These products seem to be very durable and withstanding outdoor climates. In a similar fashion Kompan and Yalp offer interactive Playground equipment. Especially Yalp provides an interesting product with their Sutu, an interactive pressure sensitive low-resolution LED wall. The system is able to make an estimate of how hard a ball is kicked, and provides multiplayer games related to soccer, e.g. taking a turn shooting a ball bouncing from the wall, it has also been used in TV shows (e.g. FoxSports). Besides these physical installations there is a plethora of interactive camera-based systems which seems less fit for physical sports exercises currently, see [van Delden et al. \(2018\)](#) for a thorough overview.

Companies such as embedded fitness, bring together such innovations and offer a variety of interactive exercises for a wide audience [\[link\]](#). Their products include a responsive LED (i.e., smartclips, similar to the system above), smartwall which is a ball sensitive projection similar to Lü discussed above, smartdance is a mat that can sense someone stepping on it, providing only visual feedback via another screen. The last product is called bloc-test, which is intended for measuring motoric performance. The

main selling point seems to be in providing simple and affordable versions of interactive sports/fitness products that could make it interesting for schools and fitness centers.

3.2. Competitors that offer interactive LED floors (for digital signage suitable for sports and leisure).

As one of the unique values of the system is the pressure sensitive LED floor, in this section various competitors providing interactive LED floor are discussed. Specifically, looking at their state regarding to sports, the provided resolution, and type of sensing, as well as estimated ease of use in repair, development, and control. One important thing in this regard is the ability to use the floor as a “regular video screen” (possible with LedGo’s hardware) as opposed to using it as a controllable array of LEDs. Next to this we notice a variety in IP ratings where IP65 includes water resistance, unlike some competitors that only provide an IP30 rating (e.g. [Infiled EZ series](#)).

Uniview LED, is a Chinese based company that provides a less expensive solution with probably higher resolution of binary presence sensing (64 points per tablet; measuring about .2 - .4m). They call this an interactive dance floor, seemingly providing a lower quality image and less sturdy solution [\[YouTube\]](#). The current floor options do not yet seem suitable for ball sports at its current implementation, most importantly missing an appropriate top layer. Installation of their platform seems to be very similar to LedGo with a few simplifications seemingly at the cost of sturdiness [\[YouTube\]](#). A USP of their floor is the ease with which the modules seem to be replaceable for repair. The content demonstrators of the floor do show various of the domains discussed in the previous section including games, dance, and a basketball floor in a flagship store [\[YouTube\]](#).

Infiled is Chinese based company that seems to provide a similar floor with demonstrating less showcases. They also provide a 5.9mm pitch (and hint at a 2.84 mm for their Dance Floor series [\[link\]](#)). A limited viewing angle of 110 degrees, is an issue for some versions of this floor manufacturer if it would be applied in most of our suggested settings [\[link Infiled ORDF5 spec sheet\]](#). Infiled provides dedicated panels for the side of sporting fields, which do have IP65 ratings. A definite selling point is the integration of cabling within the connection of one of the systems meaning that panels can be replaced without a need to rewire. This also seems to fit a primary focus on rental services [\[link\]](#). Although Shenzhen based, Infiled does have a local office in Venlo. Vue Pix is a direct partner for the Australians, with an overlapping name which does provide more detailed specification [\[link\]](#).

A series of similar products exist, some might even be repacking or distributors, in general using light or capacitive sensing for input, lacking in sturdiness, and lacking in direct control. Companies/products include: Xyglenscreen [\[link\]](#), Worldstage [\[link\]](#), Led Flatlight [\[link\]](#), iledsolution [\[link\]](#) and creuview [\[link\]](#), doivision [\[link\]](#), dynamo led displays [\[link\]](#), light energy studio [\[link\]](#), and sensacell [\[link\]](#). From which the latter does provide a nice troubleshooting explanation, which raises in the context of this report the need for adjustments once longer-term placements are planned.

Ekta is an Ukraine based company that provides an interactive floor with a similar protective layer. The pixel pitch is however quite high with 24.15 [\[link\]](#). Demonstrations also showcase similar traditional targeted domains: events, broadcast, and exhibitions.

ROE Visual, provides a similar high contrast glass floor, with anti-slip features and high pressure resistance. Unlike Uniview LED the systems seems to be similar to LedGo be truly flat [\[YouTube\]](#). Similar to LedGo they also have been working with TV grade visualizations. Similar to Uniview the detection is

based on light, resulting in a higher detection resolution (mentioning 100 sensor per .6m tile) and a slightly lower visual resolution with a “5.769mm pixel pitch” [[Roe Visual](#) or 104 per .6m versus LedGo floor 128 per .5m]. Integration is provided directly for often used tools such as Notch or TouchDesigner. Furthermore, example integrations are provided for often used applications include the game development platform Unity [[link](#)]. Another selling point similar to LedGo is the ability to easily readdress layout changes [[link](#)]. The floor also offers triangular panels which can be of added value for certain layouts. As the floor uses optical sensors the automatic calibration is done continuously. Response times are about equal with .33 Ms (versus Ledgo’s 40Ms). Demonstrations so far include only the standard domains such as broadcasts and various events etc. The competing power of this product is high as they also provide direct video control over standard HDMI, similar IP ratings, etc.

ASB is the main competitor, and seemingly currently the only provider of full-scale led floors suitable for main (indoor) sporting events. The floor with a 39 or 4.8 mm pitch can be controlled in real-time via HDMI [[link](#)]. As indicated before they passed certification processes to allow use in sport competitions, one element of this seems to be the etching for reflection, and special top layer for providing the proper bending and bouncing capabilities. To sense interaction they make use of other partners, not always clear which type is used, but it does include BlackTrax’s sequenced LED light tracking solution. This form of tracking seems to need a wearable bracelet and a surrounding camera setup [[link](#) collaboration, and [explanation](#)]. Most impressive are the showcases including various sports, where tennis is shown but not during any major event:

- Volleyball, during the German comdirect SuperCup event in TUI Arena Hannover in October 2019 [[link](#)]
- Interactive games surrounding events, interestingly the tracking seems to work without wearable [[link](#)]
- Streetsoccer, in collaboration with Uni-Liga German in 2020, showcasing manual score integration, marketing possibilities, rule-upholding (e.g. shot clock), and button-based interactions [[link](#)]
- Basketball and badminton [[link](#)]

3.3. Discussion

From the more exercise-based competition a few platforms seem to fulfill the growing interest for interaction in PE in a more cost-effective way. It will be hard to showcase the additional value in this market in such an extent that large investments can be made by these rather small organizations.

On the current high end rental side main competitors seem to be ABSFloor and ROE visual as they provide decent quality visuals based on standard real-time video streams over HDMI etc for control, and have the possibility to integrate this with real-time sensing.

An interesting aspect is that although the ASB floor can be bought for a permanent setup, most demonstrations show that the floor is used at events. Currently making use of rental solutions is also something that fits well with the current business models of LED Go. Another noticeable recurring customer of various of these products discussed above is Nike both for permanent looking shop setups as well as for rental during marketing events. The bigger (TV) sports events might provide a small additional venue, including volleyball, basketball, soccer, and WWE-like settings.

The main point on which LedGo has a lead is the capability to use pressure-based sensing. However, Roe Visual currently seems to outperform this as it uses a denser detection, although their sensing technique might be less accurate in detecting jumping as it responds after a larger threshold than foot release of floor. Unfortunately, the current set of showcases from this project do not yet clearly indicate the added value of pressure over capacitive or visual tracking, as IMUs are also needed for them. Moreover, as ASB is reliant on other forms of tracking it can be expected that their capabilities for integration will grow with rapid advances in computer vision. On the other hand, as the floor of this project still needs a more comprehensive certification likely in combination with a top layer, it has to be seen how well the pressure sensitive floor will be able to detect changes in its future version.

It seems of importance to focus in the need for more content to also showcase those where the unique pressure sensors of the LedGo floor add significant value, which was not yet found throughout the project. Furthermore, the close collaboration with excellent visualizations provided by Pivot can be good selling point to provide complete solutions. Alternatively, another point for improvement is the usability, repair, and for end-user created content example integrations. For instance, a next step would be to provide clear Hello World examples that provide access to the platform sensors and visuals beyond the protocol, allowing to directly work in OpenFrameworks, Unity, Touchdesigner, and the like.

4. Consortium

The various partners all have their strengths towards possible valorisation. LedGo, the company behind the hardware, is not only specialized in developing and marketing such hardware platforms, but also already has an extensive sales network and portfolio, and many relevant contacts towards new markets. This can play an important role especially if TV sports would be targeted.

InnoSportLab Sport & Beweeg is experienced in understanding how to achieve adoption of such novel technologies in sports and public spaces, linking opportunities for organizations and national associations with providers of technology.

UT and Windesheim have the knowledge to build more content and the teaching opportunities to take future professionals along in this development. This knowledge can be central in the longer term future where applications themselves can become a selling point. UT furthermore has NovelT, the business acceleration program that could play a role in such a direction. NovelT is a core reason that the UT is (one of) the most successful Dutch university in launching spin offs. However, key for the further valorization of the results, and in the lead, will be LedGo.

4.1. LedGo: the company behind the floor hardware

In this section LedGo is described, including its vision, mission, and distribution of products. In this a view is taken into how it could address the new market and grow into it.

The company: a brief history of LedGo

LedGo was founded in 2008 by owner Hans de Vet. In 2002 the first company to set up was PiVOT, a company that designs and plays graphic content for entertainment purposes. Because often this work relied on very bad or very expensive technical equipment (LED panels from third parties on which the content is played), he founded LedGo. LedGo started designing its own LED panels from 2008 and had them (OEM) made in China. LedGo then started to sell and rent these panels. One of the most important products that LedGo has designed was the first interactive LED video floor. It was unique in the world at the time. This was used at the Voice and the Eurovision Song Contest, among others.

The company has now developed many more products, the next unique product (patented) being the Interior Panel Ceiling panel. This is a product designed to fit exactly in standard European suspended ceilings. This is suitable for retail applications, museums, etc.

LedGo works for the international market with a comprehensive distribution and dealer network, leading to the following core of LedGo:

Vision of LedGo- Together with subsidiary Pivot, LedGo is able to create, visualize and implement progressive and unique experiences.

Mission of LedGo - Let people experience a unique visual experience, using our experience in design and hardware.

Core activities LedGo - Designing, producing and assembling innovative LED video products, and selling and renting them.What makes the new LedGo floor special.

LedGo Floor

Due to the extensive knowledge of LED, high-quality LEDs were chosen for the floor product in combination with a front layer specially designed by LedGo, so that it can also be walked on. The front layer also ensures that the colors are properly displayed and the viewing angle is increased to 180 degrees.

The product is unique in part because of the interactivity that is built in. Ledgo has designed unique sensors which can measure the energy (force) and the location of the activity on the floor. As a result, special effects can be generated and this interactivity can also be applied for many different applications. Ledgo is unique in the world with this interactive application and so interactive games can be played that take into account not only the position of a person (as with some of the visual solutions discussed previously) but also the forces associated with it. This offers many possibilities for the use of the floor. Think of sports and games, but also rehabilitation.

Current and future markets

There are several markets from which customers have shown an interest in such a product.

1) The entertainment market

The use of the floor is interesting for the entertainment market in a broad sense, such as the TV market, public events, trade fairs and corporate events, concerts, but also as a special feature for companies or wealthy individuals in their homes, boats or planes (i.e., as an entertainment device in public buildings to make it more interesting / pleasant).

2) The sports market

As shown in the project the floor can be integrated allowing measurements of various activities during training (proxemic/running behavior of athletes, jumping timing, number of times in area x). Although follow-up studies are needed in theory and based on interviews, there are clear indications that this can positively influence sports performance. In addition, it is possible by putting content on the floor to increase the gaming experience for players or to facilitate exercises. The floor is also suitable for making training modules so that athletes can improve their skills. The commercial value is also increased by placing advertisements on the floor. Video clips (replays) can also be displayed during the game so that the audience keeps looking at the field and does not have to look up at a screen hanging in the air. In a similar fashion scoring and shot clocks can be integrated.

3) The medical market

The floor is interesting in medical rehabilitation because it can measure how people move including balance to some extent and, for example, with what values of sensed pressure people walk on the floor. Through a specially designed game, the rehabilitating people can be motivated to make certain movements which might contribute to a faster recovery, which is potentially also interesting for insurance parties. After all, less every day in rehabilitation saves a lot of money. Moreover, all kinds of information can be fed back to stakeholders via the data.

4) Education / Research market

The data on the behavior of people on the floor are particularly can be interesting for this market. The entertainment appearance and lack of need for computer vision, can make it more accessible for

research in those cases that people should have less resistance to having things measured. The data following from such studies could be used in various ways. Furthermore, it can function as an eye catcher in state-of-the art institutes.

5) Digital Signage market (routing, signage, advertisements, etc.)

For this market, the fact that, for example, escape routes or other routes can be indicated, as well as advertising opportunities are interesting. In addition to the fact that data on the number of visitors can also be measured, attracting people is interesting for the shopkeepers. This could for instance include the malls and flagship stores seen in the competitor analyses, as well as airports and event locations.

The floor has both an informative and commercial application for this market.

Distribution

LedGo works with an international distributors and dealer network. The parties that operate as dealers are generally system integrators, parties who take care of the complete furnishing / installation of a building, boat, or event location.

Moreover, LedGo also works with international AV rental companies (who rent out audio, video and lighting facilities). They are also dealers themselves. Various sales processes are currently underway in the previously described market segments.

Size of the sales market

The sales market is very diverse and scattered all over the world. A few examples include: information provision in museums, extra audience attracting in shopping centers, luxury interiors, discotheques, television shows, entertainment, etc. Ledgo already operates in these market segments and has already done several installations. With the development of the sports floor, the sports market will also become a target group. The volleyball and basketball federation are already involved in this and keep a close eye on the development. They will be the early adapters in this market and thus be the springboard to the big market.

Ledgo has a large number of requests for the various installations worth more than € 10,000,000. Unfortunately, due to the global corona pandemic, almost all applications are on hold, after all, the floor is intended for places where people come together. The entire entertainment industry has been hit hard and it is difficult to predict when the effects of corona will be over regarding social distancing as well as and how soon the economy will recover.

4.2. Foundation “InnoSportlab Sport & Beweeg”

The non-profit foundation InnoSportLab Sport en Beweeg has the mission to use innovations to make sports and exercise self-evident, and thus to realize sporty, social and economic returns. Because although the positive effects of sport and exercise have clearly been proven, these are still insufficiently motivating for too many people to exercise more sustainably. InnoSportLab Sport & Beweeg therefore develops innovations that effectively stimulate sports and exercise. We connect new technological possibilities with the unique forces of sport, such as play (gaming), competition and social connection.

Since 2017, InnoSportLab Sport & Beweeg has been part of the national Sportinnovator network, recently confirmed again with the recognition as a certified partner. In both the national and regional

Sports & Technology network, InnoSportLab Sport & Beweeg distinguishes itself by its focus on developing innovations:

- for the stimulation of unbound sports and exercise, with particular applications in public space;
- using the power of the Brainport region: technology, design & knowledge.

InnoSportLab Sport & Beweeg has proven for years to be an expert and skilled partner in the innovation domain of sports and exercise stimulation. In research projects, the lab frequently collaborates with universities and colleges, and at the same time is able to make the resulting innovations yield economic and social returns. It is precisely in this transition area from innovation to market (public, private) that the lab fulfills a unique link in the national sports innovation landscape and can contribute to bringing the SSE solution to the market.

4.3. Our joint network of relevant parties

To access the new markets practical use can be made of existing networks mainly from LedGo but also building on the other partners. For instance, the UT was contacted about interactive elements for new sports center(s), Windesheim was contacted during the dissemination workshop about possible collaborations for instance with sports equipment distributors such as BOSK, and finally via InnoSport close contact is kept about upcoming events and interests from clubs, and especially national associations/federations.

Network of LedGo

LedGo has built a worldwide network. This is partially based on their yearly participation at the main trade fairs (e.g., ISE) where the major AV players on the market are gathered. Within this network, LedGo can very quickly promote and sell all products.

LedGo's distributors and dealers are active in all mentioned markets, both nationally and internationally. However, these parties are currently purely focused on selling hardware. The interactive software applications are currently not yet available. Therefore, it is not yet possible to offer a total solution for international sports associations or educational institutions that immediately helps them with the most effective / interesting use of the floor.

If a combination can be made with hardware and good content (software), this also offers many opportunities internationally. Probably quickly going beyond the national borders, due to the size of the market and financial possibilities.

In the next section several ideas on how this shortcoming of only a limited set of demonstrators can be used as a long term plan with the right partners to in a constructive way work towards the combination of data understanding and professionally informed triggering of the right exercises.

5. Business and financial

Interactive, data-based training is on the rise and with growing professionalization and money involved in various sports becoming more and more important. The SSE-solution can also be developed further to offer more data analytics integration; data analytics is important for building winning teams; and the SSE platform offers data that can be used in the analytics to go beyond camera and IMU solutions where more information on floor contact and in the future possibly even estimates of ground reaction forces

can be integrated. This will play an important role in providing a business model for providing expert-based software, as it might on the longer-term show training effects and injury prevention in a quantified way.

For this business and financial model it is important to realize that for clubs and athletes this is all very interesting, but who would buy the actual floor, which is too expensive for this purpose only, and when integrated in sports center not very mobile?

The short-term answer to this will be that the floor can be placed in several surroundings it is mobile *enough* for rentals, but it takes time and expertise to move it around. Therefore, it could be interesting to use it, as was already seen for the ASB floor, during large events such as national and international finals, as well as bigger championships in big event halls (e.g. [nationally](#) Ahoy, Ziggo Drome, the German Tui Arena Hannover, Belgian Sportpaleis, and various stadiums in the US, see [capacity](#)). This fits closely with the way LedGo works and provides a constructive way to build towards a representable share in the new market. During these events showcases such as (was) planned for our current demonstrators can be given to inspire the big clubs (e.g. NBA) or the handful of large professional indoors center per country (e.g., Omnisport, MartiniPlaza, Eindhoven) to invest with a few teams together (cf. recent investment in top level lighting installation [at MartiniPlaza](#)). Here it is important to look back at the added value beyond exercises as already with little to no investment marketing, scoring, and field layouts that are offered by the competition can be integrated in a vamped-up style making use of the origins of Pivot as a state-of-the-art visual show provider.

5.1. Market / customers

The high-end customers are most likely to use the floor and are able to pay for it. It could be interesting to investigate if there are any financial parties who are willing to buy the floor and rent it to these sports events or even teams/companies. This is a step where the consortium is actively looking into; as it would safeguard the major investment needed for a full-fledged rental floor. Instead, the investments from LedGo can then be kept at a minimum and instead be used to keep on going improvement of hardware and providing visualizations, needed to hold off the current market leader in this segment ASB floor, as well as likely upcoming competition once the road is paved. In short finding the right distributors, event partners, and system integrators would make possible to have a viable business model without an unacceptable risk for LedGo alone. As discussed here the trade fairs and the existing network play a key role, and this shared approach is something that is high in the priority list.

Next to this a more thorough market research than currently done with the consortium is very important; to be able to introduce the floor to the most interesting parties. Furthermore, with the right story and video materials of the demonstrators the conversations can be guided about the additional specific needs that the market has, in terms of hardware, software, content, data, control, and even alignment in business models. Two main routes to proceed in that direction are being explored: 1) contact a sports marketing company to join the consortium, or 2) have direct conversations to talk about the long-term possibilities for the top-venues in Europe and set out surveys to top sport teams nationally and internationally. An additional approach would be to look at lighter versions of the SSE solutions that use alternative, less high end hardware for providing feedback to athletes – getting customers to invest in this might form a gateway to them getting interested in the more expensive, but also more high end and versatile full solution with the floor hardware.

Besides this track closely related to the core of the SSE project, the increased knowledge of combining IMUs with floor data also triggered a continuous investigation in a possible market at rehab centers: from the approximately 260 different rehabilitation centra [[zorgkaart](#)] most are financially too small for a reasonable size floor, thus only the bigger ones could be of interest as a plausible customer (e.g., Basalt, Klimmendaal, Roessingh, Hoogstraat, Rijnlands, and Sint Maartenskliniek). Although interesting currently there is no clear paved way to get into this market, and especially with additional certification needs it will be hard to get hold on.

5.2. Financial picture of valorisation

Most parts of the system are of very high-quality and historically oriented towards the upper segments of the market. As indicated above this requires serious investments and thus also a reasonable expectation of return of investment. The sports-oriented picture only would be hard to fill this picture. Instead, it could more easily be filled with the kind of advertisement module exploited by specialized event and sports marketing company (e.g., like is the approach for the large screens at train stations and other public spaces where the provider of hardware and dealer of advertisement place a closely knit symbiotic system). The core here is when the floor is used in competitions with a large audience. For instance, according to some estimates sponsorship in NBA alone are over a billion dollar industry per year [[statista 2020](#), [athletic business 2017](#)] (although seemingly including TV-related outlets such as interview screens and augmented on field-placements). Nonetheless, the NBA alone has 21 million visit(or)s per year [[statista](#)] which makes it a viable market for additional marketing outlets, especially those that get noticed such as half-time dynamic visual extravaganzas. Unfortunately, note that as interactivity is not such a thing and contact with the consortium is already slowly getting started towards this direction, ASB might sweep the floor by being the initial provider of this market.

Nationally selling towards sports center, as mentioned above, is somewhat more limited as there are only a few with 3k+ capacity; instead it might make use of the fact that multiple clubs can play in the same stadium (in NL seemingly mainly volleyball and basketball). A business model to work-out in more detail to convince all parties involved is that the clubs could pay membership fees to use the location, with added rent or pay-per-use for extra content whereas marketing revenue by location-based sponsorship thus ends up at both.

Up to the point that these investments are made for the bigger centres, the rental approach could be a solution for national teams etc. To our current estimates for regional teams for now this seems unlikely, although there is some possibility for generation of advertisement money from local companies. It becomes somewhat more likely if the teams/matches are interesting for television and new ways of advertisements can be offered (cf Adi's virtual hybrid LEDs where in-stadium and television sponsorships can differ, even per region due to the technological combination used).

In short for dedicated purchase the sports for which the floor is most suitable to use are not so realistic currently in the Netherlands. Instead, if you would compare it to basketball in the USA the commercial possibilities are becoming more viable.

Regionally in Europe, travelling with floors to key events will be the short-term business model (events at location) or events and renting in the sports facilities where we have a fixed floor as part of the business model. This is very similar to the events already targeted currently such as the European Song festival, but likely also concerts in stadiums; and seen in street basketball shows; finals of National

volleyball or handball league(s), fighting shows; and possibly other showcasing events (often in context of big championships) could be possible which have not already been covered by the competition or LedGo. One sure area fitting the high-tech and visual capabilities, would be the rising interests in eSports with 20 million and over livestreamers as well as 300k+ visitors per event, the upcoming EK Futsal 2022, and the full 15k in the Cologne arena [ESL 2019] . Currently many of these events, especially sport events, already rent dedicated temporary floors among other for television broadcasting reasons without showing additional field lines. In this context, LedGo already has a relation with the French company GerFlor which is the preferred supplier for the world volleyball association (FIVB).

5.3. Market place for new apps

Besides partners for the hardware, serious considerations and interests in collaborations with external partners are investigated to more quickly grow a market with the many games. This partnerships would be needed to make something like this land not only in the advertisement but in a broader sports environment.

Similar to other competitors (e.g. ROE Visual's seeming ease of use) providing example SDK integrations and code for demo programs can heighten possibilities for opening up the platform for 3rd party exercise developers to give the work more reach and facilitate bigger growth of market. If the project shows one thing, it is not the limitation in possible exercises that plays a role but the translation needs to be well-grounded from technical, player, and coach style. Furthermore, any limitation plays an important role if 100s of games and exercises are needed with accompanying tailoring. This might not only require integration of the higher level data but also new integrations and access for development, by providing an accessible platform, examples, API, and SDK so external partners can develop new training games and can depend on the core platform with its sensing etc remain accessible in a stable way making use of the most minute details, without breaking any confidential or intellectual property. This is a challenge and balance, yet to be worked out in more detail, as this requires serious effort, thus also awaiting for the right requirements and needs to tip the balance towards the less technical and more implementable side. On the other hand, as is recognized in Section 2 without the wide-area of demonstrators and provision of content it is hard to persuade even the most financial capable sports centres in the Netherlands.

Organizationally one solution on the longer term could be some kind of “**app market**” setup with a shared revenue model (similar to Facebook's Quest, Play store and Apple Store). In such a solution the platform is initially sold to a sports center including a standard set of training exercise modules, and the sports center/or clubs can buy add-ons or add-ins with additional vetted training games and data acquisition and analysis modules – this could give incentive for 3rd party developers to make more games, which in turn makes the use value of the SSE platform larger as well.

5.4. Community perspective into the app market

Once an apps store or reachable platform is setup, there is also a “how do I use this in my club” question from users. This means there would not only be an app layer but also a social embedding and facilitation—share experiences between clubs. Clubs and trainers cannot program, however still they can make their own exercises once the tools offered by the platform are useful, usable, and accessible without technical expertise. For the success of this, tailoring and example programs are key. Compare this to the successfully growing market of end-user created content in education.

Perhaps an open mixed model is most likely to result in a success, where people can add either free or more professionally finished paid content as they wish, where the content may consist of software / games / interactive training exercises as well as training plans and suggestions for lessons making use of that software. In the latter case only with the community layer this can be a success (cf. app store models). Furthermore, the community is key to get not only the current possible-users on board but also by word-of-mouth provide request from bottom-up.

6. Conclusion

The demonstrators provide an impressive show of possibilities that help convince and explain the enormous opportunity. In the valorization report several ways to monetize this without too much risk are indicated, however some element continue to be a intrinsic balancing act from providing detailed data to protecting intellectual property, and from providing ready-to-use content to giving end-user tailored access, from investing in the floor to collaborating but waiting for other parties, from investing in a top sport classification to balancing risks of investments. The key role is to continue making use of the strong network to take a starting spot in the market place so Smarts Sports Exercise can accelerate development of training games as well as boost venues for a new a collective of sports data-scientists, sports pedagogy games, and usable engaging sports interactions.