

Wearable, Mobile, and Fixed-Location Technology by Sport for Coaches and Trainers

The New Home Field Advantage: Part 2
Fitness & Sports Wearable Technology (FAST) Expo II, July 22, 2014
Robert A. Connor, MHA, Ph.D., CEO, Medibotics LLC
robert.connor@medibotics.com





"Don't look back. Something might be tracking you."

(inspired by Satchel Paige)

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

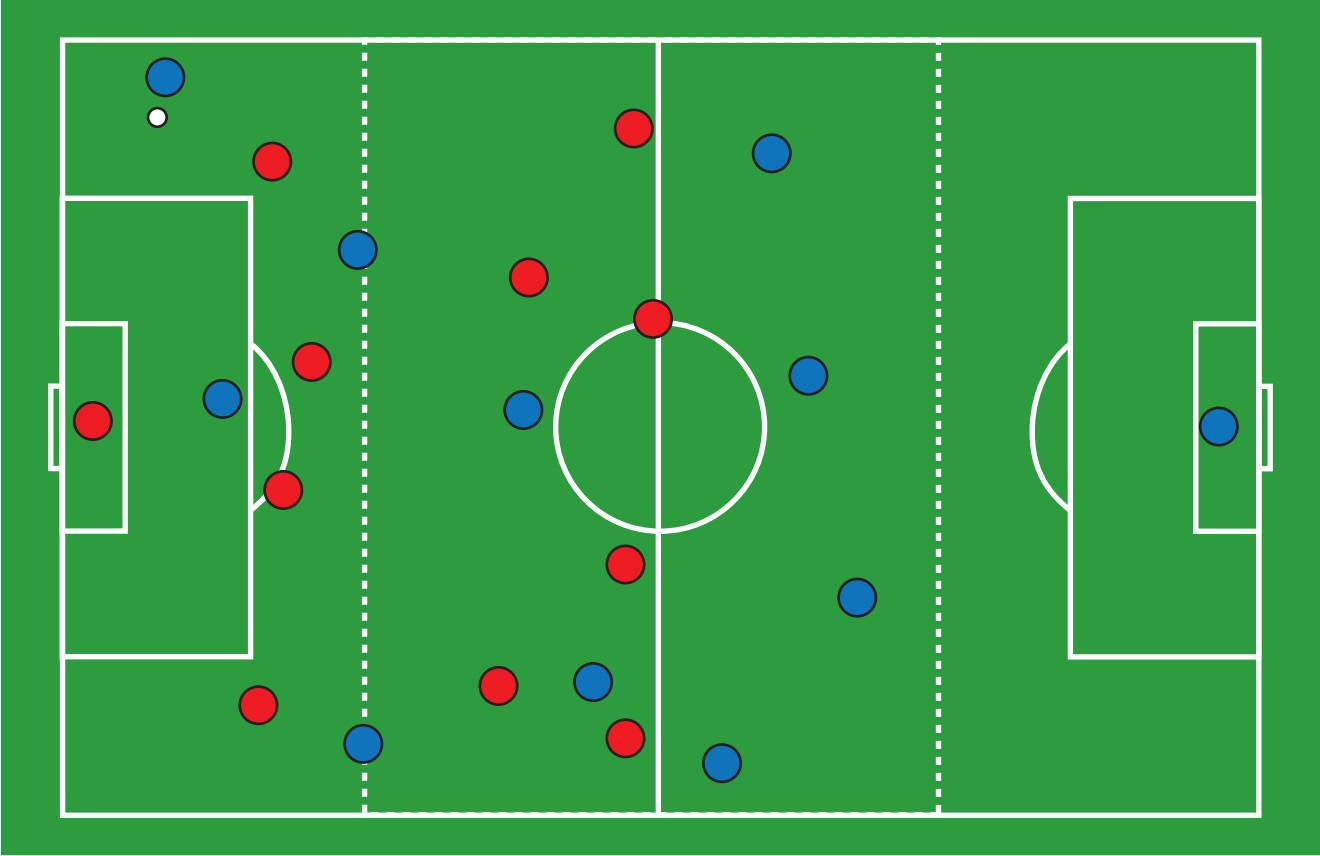
TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

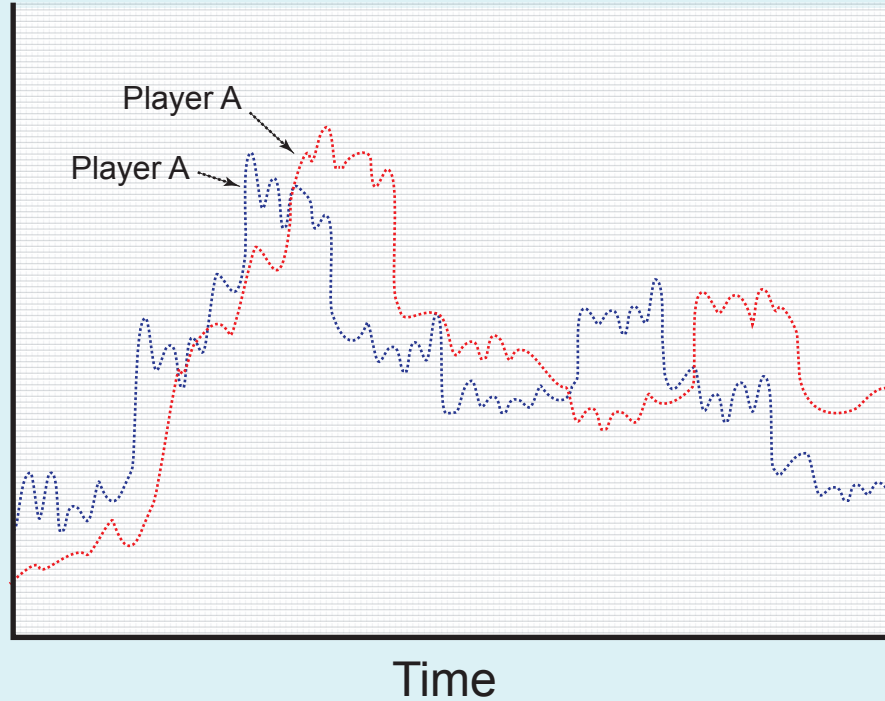
INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement



Motion
Metric
(function
of change
in location)



Physio-
logical
Metric
(function
of heart,
respiration,
other)

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

"Win at Home and Draw Away"

Automatic Formation Analysis Highlighting the Differences in Home and Away Team Behaviors

Bialkowski et al. (2014),
MIT Sloan Sports Analytics Conference, Feb-Mar, 2014

* Soccer. Two factors. (1) **Team formation** (e.g., 4-4-2, 4-2-3-1, 3-5-2 etc.). (2) **Manner of execution** (e.g., conservative -- sitting deep, or aggressive -- pressing high).

* Season of Prozone data. **Ball and player tracking**. Top-tier professional league. **Automatic formation detection** method. **Investigate "home advantage."**

* Teams tend to play same formation at home as away, but execution of formation is different.

* Position of **team significantly higher up the field at home** compared to away. Conservative approach away suggests coaches aim to win home games and draw away games.

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

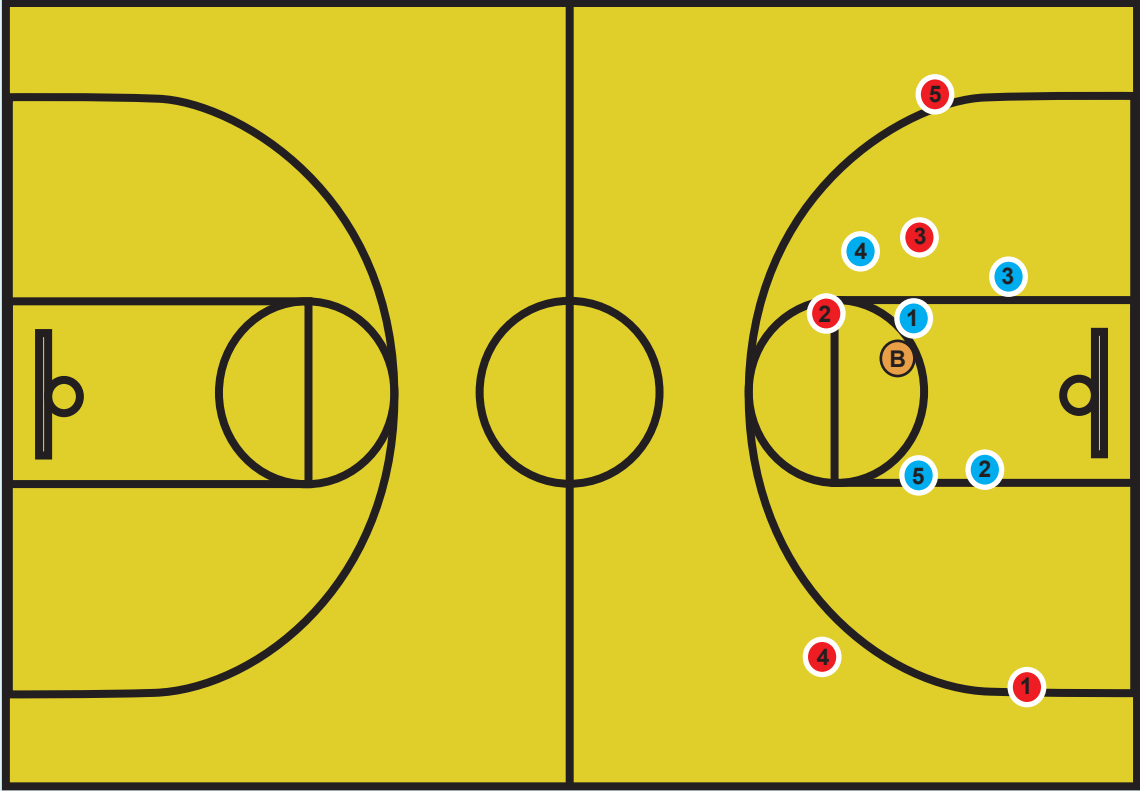
TECH MODE:

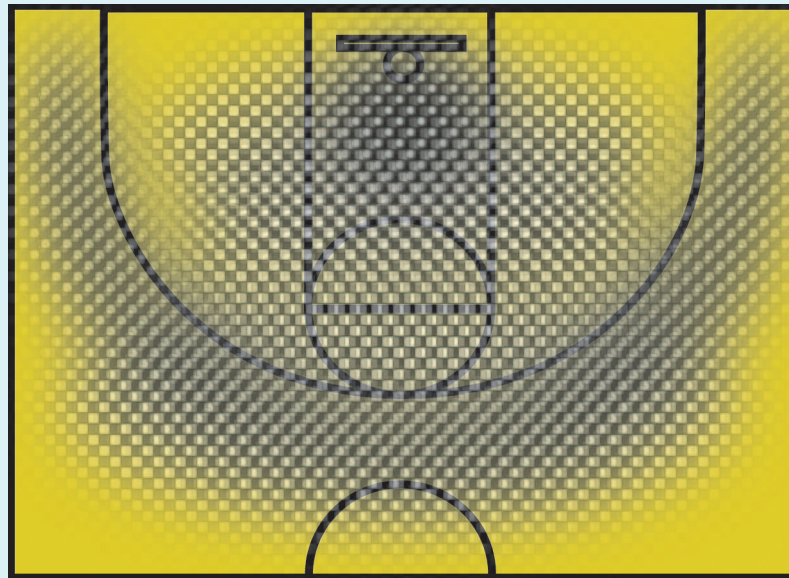
- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement





SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * **Baseball**
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * **Fixed Location (Multiple Cameras in Arena, etc.)**

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * **Ball/Equipment (Location, Speed, Orientation)**

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * **Football(US)**
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * **Wearable** (Wrist, Strap, Clothing Pocket, Clothing Fabric, **Helmet**, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, **Pressure**, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, **Injury Avoidance**, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

TECH MODE:

- * Wearable (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

INFO:

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

SPORT:

- * Soccer(US)=Football
- * Basketball
- * Baseball
- * Football(US)
- * Fitness/Strength
- * Running
- * Golf
- * Cycling
- * Hockey
- * Rugby
- * Skateboarding
- * Skiing/Snowboarding
- * Tennis

FUTURE TECH?

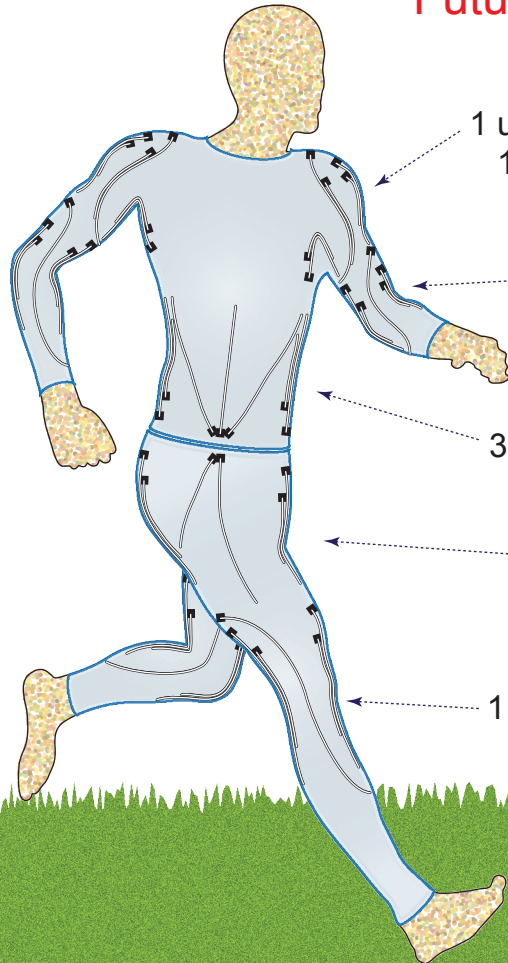
- * **Wearable** (Wrist, Strap, Clothing Pocket, Clothing Fabric, Helmet, Adhesive Strip, etc.)
- * Mobile (Handheld, Attached to Ball/Equipment, Imbedded in Ball/Equipment)
- * Fixed Location (Multiple Cameras in Arena, etc.)

FUTURE INFO?

- * Player Single Point (Location, Distance, Speed, Acceleration, Path, Up/Down ~ "Steps")
- * Player Full Body (Orientation, Posture, etc.)
- * Player Physiology (Heart, Respiration, Blood Pressure, Oxygen, EMG, Pressure, etc.)
- * Ball/Equipment (Location, Speed, Orientation)

APPLICATIONS: Training, Health Improvement, Injury Avoidance, Player Selection, Play Strategy and Improvement, Recruitment, Call Evaluation, Fan Engagement

Future Mobile Full-Body Motion Recognition?



Shoulder (each) Longitudinal Sensors:

1 upper long, 1 upper short, 1 lower long, 1 lower short
1 front long, 1 front short, 1 back long, 1 back short

Elbow (each) Longitudinal Sensors:

1 inner long, 1 inner short, 1 outer long, 1 outer short
2 central twist long

Torso Longitudinal Sensors:

2 side long, 2 side short,
3 central twist front long, 3 central twist back long

Hip (each) Longitudinal Sensors:

1 front long, 1 front short, 1 back long, 1 back short,
2 side long

Knee (each) Longitudinal Sensors:

1 front long, 1 front short, 1 back long, 1 back short,
2 side long

Soccer(US)=Football(Intl.): Companies and Applications

TECH MODE: COMPANY/PRODUCT:

- Wearable ► Adidas/miCoach
- Wearable/Mobile/Fixed ► Cairos Tech
- Wearable ► Catapult Sports
- Fixed ► Deltatre/Matrix
- Fixed ► STATS LLC/SportVU
- Fixed ► SUP/Prozone
- Fixed ► HawkEye
- Mobile/Fixed ► GoalRef
- Fixed ► Match Analysis/K2 Panoramic Video
- Wearable ► MC10/Biostamp?
- Wearable ► Beestar/QuASP
- Wearable ► Google/Glass?
- Wearable/Mobile ► Panasonic/HX-A500
- Wearable/Mobile ► SAP/HANA

Basketball: Companies and Applications

TECH MODE: COMPANY/PRODUCT:

Fixed ► STATS LLC/SportVU

Wearable ► Catapult Sports

Wearable ► Digital Sports/ShotTracker

Wearable ► Hoop Tracker

Mobile ► Infomotion Sports/94Fifty

Wearable ► Vibrado

Wearable ► Zephyr/BioPatch?

Baseball: Companies and Applications

TECH MODE: COMPANY/PRODUCT:

- Fixed ► Sportvision/PITCHfx
- Fixed ► Sportvision/HITfx
- Fixed ► STATS LLC/SportVU
- Mobile ► Blast/Swing Trainer
- Wearable ► Catapult Sports?
- Wearable ► MC10/Biostamp?
- Wearable ► Northeastern/Pitcher Shirt?
- Mobile ► Zepp/Baseball

Football(US): Companies and Applications

TECH MODE: COMPANY/PRODUCT:

- Wearable ► Catapult Sports
- Wearable ► FITGuard
- Wearable ► GPSports
- Wearable ► i1 Biometrics
- Wearable ► Mamori/Mouthguard
- Wearable ► MC10/Biostamp?
- Wearable ► MC10/Reebok/Checklight
- Fixed ► Sportvision/Optical Player Tracking
- Fixed ► STATS LLC/SportVU
- Wearable ► X2 Biosystems
- Wearable ► Zebra Technologies
- Wearable ► Alert Shirt
- Wearable ► Real Track Football

[article] Solomon (2013), "SEC, Pac-12 and Big 12 will Electronically Track Football Players' Speeds and Movements"

Fitness/Strength Training/Running: Companies and Applications

- ▶ Adidas/miCoach ▶ Fitbit ▶ Intel/Basis Science ▶ Jawbone/BodyMedia
- ▶ Nike/Fuelband ▶ Sensoria/Smart Socks ▶ Carre/Hexoskin
- ▶ **PUSH Design/Armband** ▶ Clothing Plus+ ▶ Misfit/Shine ▶ Moov
- ▶ New Balance/Cardio ▶ OMsignal/Shirt ▶ Polar ▶ Samsung/Galaxy Fit
- ▶ Thalmic Labs ▶ Under Armour ▶ Zephyr ▶ Amiigo ▶ Athos ▶ Bowflex/EX Pro ▶ Fitbug ▶ FitLinxx ▶ Garmin ▶ Gruve/Muve ▶ Lumo BodyTech
- ▶ Neptune/Pine ▶ Notch ▶ Preventice ▶ Qualcomm ▶ Reebok ▶ Runner Groove ▶ Samsung/Galaxy Gear ▶ SONY ▶ TITIN/Shorts ▶ Ware LLC
- ▶ Withings/Pulse ▶ LG/Lifeband ▶ Google/Watch? ▶ Microsoft?
- ▶ Samsung/Simband? ▶ Google/Glass? ▶ Apple?

Golf: Companies and Applications

TECH MODE: COMPANY/PRODUCT:

- Wearable/Mobile ► Active Mind/Game Golf
- Mobile ► Mobiplex/SwingTIP
- Wearable ► Zepp/Golfsense
- Fixed ► GolfTEC
- Mobile ► GreenPlay
- Wearable ► Medibotics?
- Mobile ► Seiko Epson/M-Tracer

Selected Other Sports: Companies and Applications

SPORT: TECH MODE: COMPANY/PRODUCT:

Cycling	Wearable ► Zackees
Hockey	Fixed ► Snapshot
Hockey	Wearable ► Catapult Sports
Hockey	Wearable ► MC10/Biostamp?
Hockey	Fixed ► STATS LLC/SportVU?
Rugby	Wearable ► Catapult Sports
Skate/Snow	Mobile ► Krack
Skate/Snow	Wearable ► Recon/Snow2
Skate/Snow	Wearable ► Trace
Tennis	Wearable ► Smash
Tennis	Mobile ► Zepp

Other Wearable Tech:

▶ 3DSuit/Innalabs ▶ AiLive ▶ AiQ/Smart Clothing ▶ Animazoo ▶ APDM
▶ Applied Technology Holdings ▶ Autographer ▶ Biomedtrics ▶ Biopac
▶ Dynamic Athletic Research Inst. ▶ EMGSrus/Motion Lab ▶ Heapsylon
▶ Impact Sports Technologies ▶ Innalabs/3DSuit ▶ InterSense ▶ iON Air
Pro Camera ▶ K-Motion Interactive ▶ MicroStrain ▶ Midland Action
Camera ▶ Narrative Clip ▶ NeuroSky/MindWave ▶ Neurowear
▶ Noraxon ▶ NDI/Ascension ▶ Parashoot ▶ Physical Enterprises
▶ Pivothead ▶ Plantronics ▶ Polhemus/Alken ▶ Tactonic Technologies
▶ TechnoSkin ▶ Trakus ▶ Xsens ▶ ZXY Sport Tracking

Other Fixed Location Tech:

▶ Active Analysis ▶ B & L Engineering ▶ Charnwood Dynamics
▶ ChyronHego ▶ Elite Sports Analysis ▶ EON Reality ▶ Kizanaro
▶ MasterCoach ▶ Mikromak ▶ Motion Analysis Corporation ▶ Motion Reality
▶ Pfinder ▶ Scanball ▶ Sports Data Hub ▶ SportsBoard ▶ Vicon ▶ Vuzix

Soccer(US)=Football(Intl.): Articles for Tech-Related Analysis and Strategy

Bialkowski et al. (2014), "Win at Home and Draw Away" Automatic Formation Analysis Highlighting the Differences in Home and Away Team Behaviors", MIT Sports Conference.

Basak (2014), "U.S. Soccer Team Tracks Movement to Prevent Onset of Injury"

Fonseca et al. (2012), "Spatial Dynamics of Team Sports Exposed by Voronoi Diagrams", Human Movement Science

Frencken et al. (2011), "Oscillations of Centroid Position and Surface Area of Soccer Teams in Small Sided Games", European Journal of Sport Science

Frencken et al. (2012), "Variability of Inter-Team Distances Associated with Match Events in Elite-Standard Soccer", Journal of Sports Sciences

Frencken et al. (2013), "Size Matters: Pitch Dimensions Constrain Interactive Team Behaviour in Soccer", Journal of Systems Science and Complexity

Lemmick et al. (2013), "Tactical Performance Analysis in Invasion Games: Perspectives from a Dynamic System Approach with Examples from Soccer", Routledge Handbook of Sports Performance Analysis

Oliver et al. (2013), "Assessing Team Strategy Using Spatiotemporal Data", 19th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining

Randers et al. (2010), "Application of Four Different Football Match Analysis Systems: A Comparative Study", Journal of Sports Sciences

Reilly et al. (2007/2009), Science and Football VI, the Proceedings of the Sixth World Congress on Science and Football

Siegle (2013), "Design of an Accuracy Study for Position Detection in Football", J of Sports Sciences

Basketball: Articles for Tech-Related Analysis and Strategy

mainly using STATS LLC/SportVU data

Bocskocsky (2014), "The Hot Hand: A New Approach to an Old "Fallacy"", [MIT Sports Conference](#)

Boudway (2013), "The NBA Will Now Track Every Player's Movements", [Business Week](#)

Cervone (2014), "Pointwise: Predicting Points and Valuing Decisions in Real Time with NBA Optical Tracking Data", [MIT Sports Conference](#)

Dubin (2012), "Basketball Enters the Space Age", [ESPN.go.com \(TrueHoop\)](#)

Fisher (2013), "Missile-Tracking Tech Fuels Stats", [Street & Smith's Sports Business Journal](#)

Goldsberry (2012), "CourtVision: New Visual and Spatial Analytics for the NBA", [MIT Sports Conference](#)

Lowe (2013), "A New View: The NBA Will Install STATS LLC Cameras in Every Arena in the League", [Grantland](#)

Lowe (2013), "Lights, Cameras, Revolution", [Grantland](#)

Lowe (2013), "Seven Ways the NBA's New Camera System Can Change the Future of Basketball", [Grantland](#)

Lowe (2013), "The SportVU Follow-up: Answering the Most Common Questions...", [Grantland](#)

Maheswaran (2012), "Deconstructing the Rebound with Optical Tracking Data", [MIT Sports Conference](#)

Maheswaran (2014), "The Three Dimensions of Rebounding", [MIT Sports Conference](#)

Mason (2011), "Optical Tracking Data and the Importance of Screening in the Boston Celtics' Offense", [Hoopspeak.com](#)

Maymin (2013), "Acceleration in the NBA: Towards an Algorithmic Taxonomy of Basketball Plays", [MIT](#)

Sports Conference

McQueen (2014), "Automatically Recognizing On-Ball Screens", MIT Sports Conference

Weil (2011), "The Importance of Being Open: What Player Tracking Data Says about NBA Field", MIT Sports Conference

Wiens (2013), "To Crash or Not To Crash: A Quantitative Look at the Relationship Between Offensive Rebounding and Transition Defense in the NBA", MIT Sports Conference

[other data] Bourbousson et al. (2010b), "Space-Time Coordination Dynamics in Basketball: Part 2. The Interaction between the Two Teams", Journal of Sports Sciences and Bourbousson et al. (2010a), "Space-Time Coordination Dynamics in Basketball: Part 1. Intra- and Inter-Couplings Among Player Dyads", Journal of Sports Sciences

Baseball: Articles for Tech-Related Analysis and Strategy

mainly using Sportvision/PITCHfx data

Ganeshapillai (2014), "A Data-Driven Method for In-game Decision Making in MLB", MIT Sports Conference

Etan (2014), "What Does it Take to Call a Strike? Three Biases in Umpire Decision Making", MIT Sports Conference

Veverka (2013), "SportVision Has Unique Vision for Tech, Sports", USA Today