MIT SLOAN SPORTS ANALYTICS CONFERENCE presented by ESPN

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Characterization of Space and Time-Dependence of 3-Point Shots in Basketball

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Players Occupation Models

Introducing static and dynamic metrics to determine the occupation of a point by the players allows us to draw occupation maps and to observe the influence of inertia on occupation.

Static Occupation Model

To quantify space occupation, we introduce a continuous measure, by taking into account the relative distance of a point (x, y) to a player. This quantity, $\delta_{space}(x, y)$ is calculated as the **difference between the distance d from the point (x, y) to the closest player and the distance from the same point to the closest opponent,**

$$\delta_{space}(x,y) = d_{closest\ opponent}(x,y) - d_{closest\ player}(x,y) \quad (1)$$

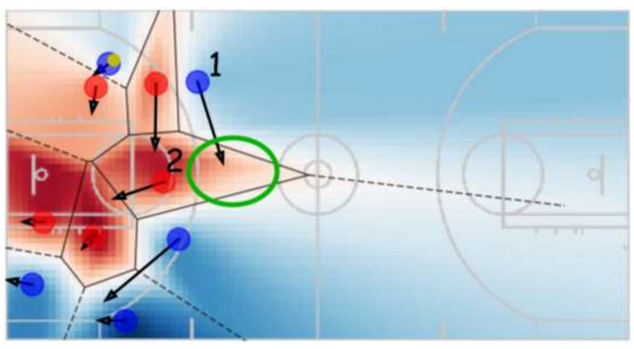
This quantity does therefore not only take into account the distance to a player, but also the fact that only players of the opposite team will dispute the control of a certain area.

Dynamic Occupation Model

The previous approach does not take into account that players have inertia. **The distance to a point does not fully define the control of a point, but it is rather the time it takes for a player to reach the point which defines the controlled area.** Therefore, space occupation of a point (x, y) is more precisely defined by a quantity δ_{time},

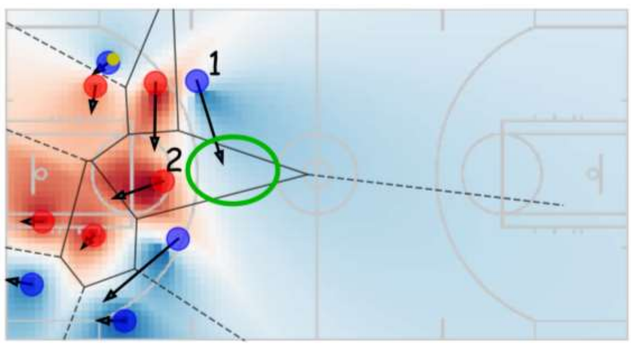
$$\delta_{time}(x,y) = t_{closest\ opponent}(x,y) - t_{closest\ player}(x,y) \quad (2)$$

where $t_{closest\ player}$ is the time it takes for the closest attacker (in seconds) to join the point (x, y), and $t_{closest\ opponent}$ the same time for a defender, both calculated taking into account players' inertia.



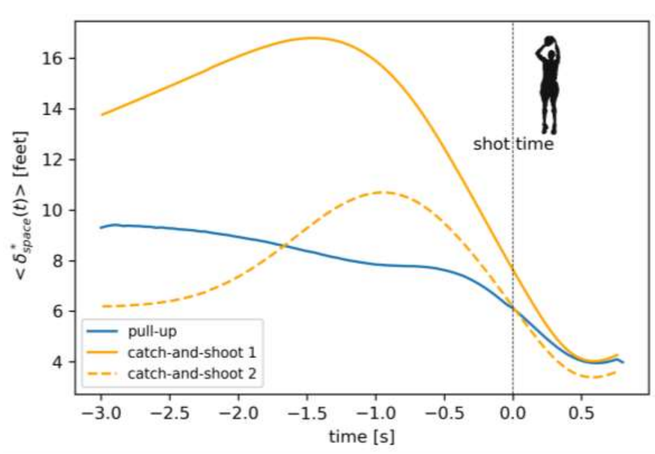
By calculating δ_{space} (left) and δ_{time} (right) for each point of the court we were able to determine *occupation-maps* describing the occupation of the court by the two teams. Black lines represent Voronoi diagrams. **Taking into account inertia (right) best fits with the intuition that offensive player (1) will reach the area inside the green circle before the defensive player (2).**

An animated version of the dynamic model is available at https://amigocap.github.io/MecaSportStats/video.mp4.



Free Space Evolution Before a 3-Point Shot

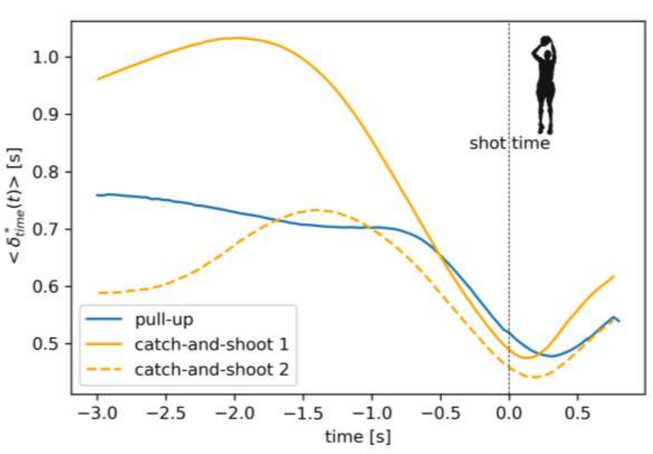
By calculating the space occupation δ_{space} and δ_{time} at the 3-point shooter's position (i.e. his static and dynamic free space), we have succeeded in highlighting 3 types of behavior for 3 different types of shots.



$\delta^*_{space} = \delta_{space}(x_{player}, y_{player})$ and $\delta^*_{time} = \delta_{time}(x_{player}, y_{player})$

Figure on the left (respectively on the right) shows average evolution of a shooter's free-space measured by δ^*_{space} (respectively δ^*_{time}) before a 3-point attempt. Shots are differentiated into three subclasses: **pull-up shots** with a global decrease as the shooter dribbles over time, **catch-and-shoot shots where the shooter has free space (1)** for a long time and **catch-and-shoot shots where the shooter has to free himself from opponents (2)** to have time to receive the ball.

Both figures reveal the same behaviors, however **a clear trend is that free space δ^*_{time} lags free space δ^*_{space}.** This difference clearly shows how inertia introduces a delay in defensive play. The precise value of the delay is 0.3s.



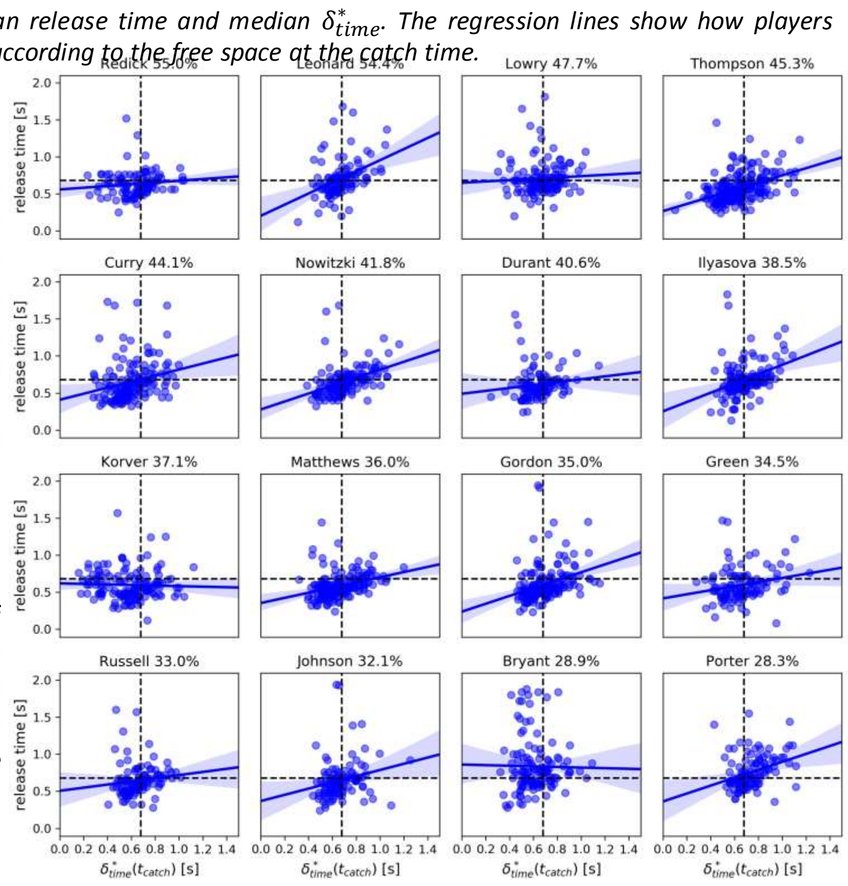
Comparing Catch-and-shoot Shooters

How does available time to shoot (value of δ^*_{time} at the time the player catches the ball t_{catch}) influences the player's release time (delay between t_{catch} and t_{shot})? The answer is that it depends on the shooter.

Dashed lines show median release time and median δ^*_{time}. The regression lines show how players adjust their release time according to the free space at the catch time.

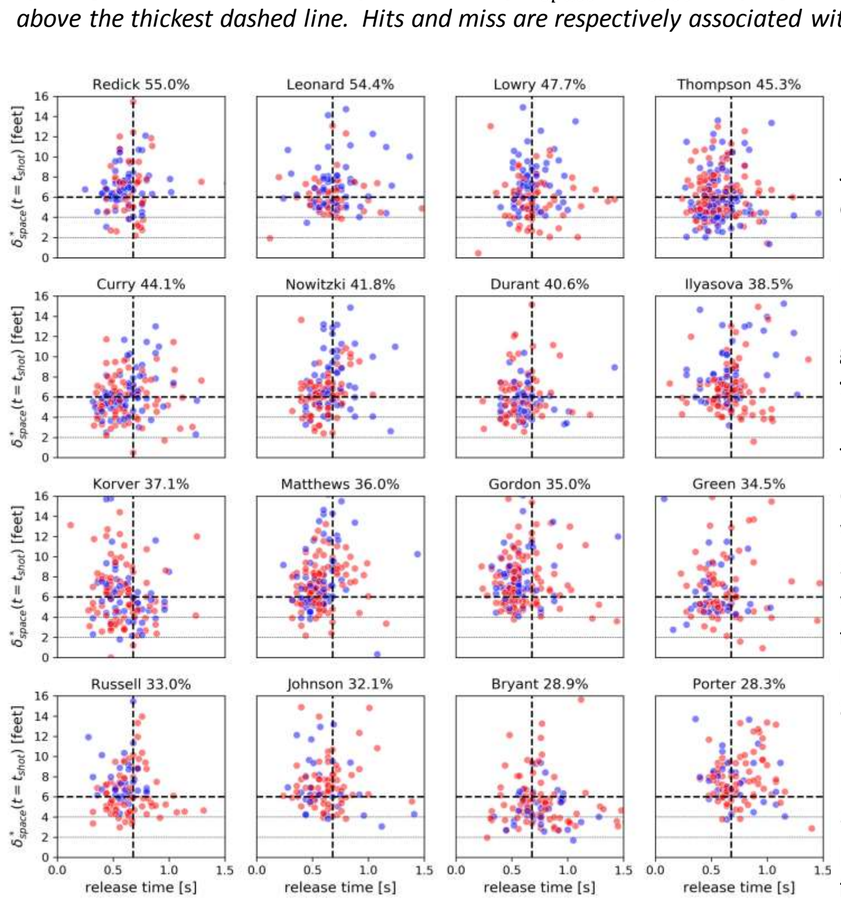
Korver **does not seem to adapt his release time to the free space he has at catch time**, while Matthews, Nowitzki or Thompson clearly **take more time if they are more free when they catch the ball.**

Players like Porter or Russell only shoot if $\delta^*_{time}(t_{catch})$ is superior to 0.5s while Curry or Korver take shots even if they are closely guarded.



Open or Closed C&S shots ? Short or long *release time* ?

Vertical dashed line shows median release time while horizontal dashed lines delimit degrees of a shot opening which is determined by the value of δ^*_{space} at t_{shot}: very tight, tight, open and wide open above the thickest dashed line. Hits and miss are respectively associated with blue and red dots.



Ilyasova, Gordon, Johnson, and Leonard **only take open shots.**

Players with a success rate **higher than 40% globally shoot quicker than the median.**

Thompson's attempts can be very tight or wide-open for the same release time while Leonard mainly takes shots when the nearest defender is 4 to 8 feet away from him.

Most of Bryant's shots are taken with the player closer than 6 feet.

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